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JOURNAL OF CYCLE RESEARCH

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GUEST EDITORIAL

Cycles in Animal Populations

The importance of an understanding of cycles in animal populations is so great economically and theoretically that a much more vigorous research programme is warranted.

Ability to predict is one of the aims of cycle research. In the wildlife field, ability to predict periods of abundance and scarcity is of very considerable economic importance. On the Queen Charlotte Islands are a number of streams in which there is a run of pink salmon in the even-numbered years such as 1948 and 1950 but none in the odd-numbered years. Operatives must be moved from the mainland to operate the factories where the salmon are canned. Without ability to predict with absolute accuracy the existence or absence of a run, the utilization of this resource might be uneconomic. Foreknowledge not only of the time of abundance but of approximate numbers also would greatly assist in planning intelligent management and the most economic utilization of wildlife resources.

The very fact that a phenomenon is periodic makes prediction possible. On the basis of present knowledge the management and utilization of some fish and wildlife species is much more satisfactory than would otherwise be the case. The four-year periodicity of Fraser River sockeye salmon, the nine-to-ten-year cycle in ruffed grouse and the four-year cycle in Arctic foxes are examples of resources that can be harvested more satisfactorily because of our present knowledge of the probable years of maximum abundance and scarcity. If there are wildlife species other than those now known in which peaks and depressions of numbers recur with reasonable regularity, discovery of such cycles will be of similar value economically. The longer the periods between peaks the less likely are they to be detected without the accumulation and analysis of statistics for long periods. The existence of some cycles may not be demonstrated because the consistent accumulation of the requisite data will not be continued long enough.

Although the knowledge that a species is abundant and scarce at reasonably regular intervals is valuable economically, even though the cause of such periodicity is unknown, knowledge of the cause or conditions associated with the periodicity gives the possibility of control. If the cause is some extra-mundane occurrence, control is more remote than if the periodic scarcity is due solely or largely to overcrowding. Petterson, for instance, correlated the long-term fluctuation in the herring fishery in the area between the Baltic and the North Sea with variations in the strength of ocean currents through the Kattegat which in turn he believed were affected by tidal influences. Fluctuations produced by such phenomena are more remote from human control than those due, for instance, to population density per se.

If we could prevent a species from periodically becoming scarce by preventing it from ever becoming too abundant, it might be advantageous to adopt management techniques that would keep its numbers at a moderate level. Whether such management would be feasible would depend on the cost of management and the level of numbers which could be continuously maintained. Knowledge not only of the existence of cycles, their length and regularity but also of their causes is necessary as a basis for management to assure maximum yield over a long period of time.

Recognition of the existence of cycles of abundance and scarcity even without an understanding of their causes tends to eliminate some types of unwise management. If regulation of grouse hunting is based on the belief that it is desirable to build up a high population for the purpose of providing a larger breeding stock, when, as a matter of fact, grouse invariably become scarce following the attainment of high populations, the folly of sparing birds destined to disappear anyway becomes obvious. The recognition of naturally recurrent cycles of abundance and scarcity may prevent waste effort and expenditure on unwise management methods.

In seeking the cause of cyclic phenomena it must be recognized that periodicities even in the biological realm are of different kinds. There is much evidence that in the case of such animals as grouse and hares, there is a gradual build up of populations over a period of years to a population peak, followed by a more or less rapid decline. On the other hand, in the case of the four-year cycle of sockeye salmon in the Fraser River, and of the two-year cycle of pink salmon in many rivers of the Pacific Coast the animals making up the populations of the peak years belong to a population distinct from that of the other years of the cycle. Four separate populations of sockeye use the Fraser River system as a spawning area in each four-year cycle. The population in the year of the big run is produced by a large population which spawned in the river four years before; similarly the small run represents the progeny of a small run. There is a succession of separate populations each of which tends to maintain its size relative to that of the other populations. This is quite a different situation from that in which one population gradually builds up over a succession of years.

There is still another type of periodicity possible, namely that in which a population peak recurs regularly as a result of a rapid increase in the year characterized by unusual abundance. Microtus, the meadow mouse, may owe most of its peak populations which seem to recur at four or five year intervals, to unusually successful reproduction and survival during a single season. Information on population changes in wild animals is not yet adequate to indicate to what extent peak populations may be due to gradual increases and to what extent they may result from unusually successful reproduction in a single season. The problems presented by these two situations might be quite different. If peak populations arise within a single season the cause is probably to be sought in ecological conditions favouring reproduction and survival in the season concerned whereas if population peaks result from a gradual build-up over a period of years, the explanation of the regularity of population changes is probably to be sought in the conditions leading to population declines.

There is no mystery about the more or less gradual increase in number of an animal if its population is low and ecological conditions suitable. The mystery is why declines occur so regularly. The really significant cyclical phenomenon is the regularity of the declines. Before we can expect to explain the reason for the regularity of population declines we must know what is responsible for the disappearance of so many of the animals constituting the peaks. Since disease is indicated as the condition leading to some declines, it is imperative to know the nature of the disease and the factors responsible for its spread. Some of the diseases are presumably spread by parasites. We need much more research in parasitology as a basis for understanding the relation of parasites to diseases of animals in the wild.

Diseases not primarily due to microorganisms have been suggested as the cause of some population declines. The so-called shock and stress diseases are examples of this type of condition suggested as causes of population declines. Other factors suggested as causes of declines include nutritive deficiencies, changes in the amount or nature of the light, and variations in the amount of ozone in the upper atmosphere. If some or all of such factors are responsible they will presumably act through their effect on the health and/or reproduction of the animals. Before we can establish the ultimate causes of declines, much more extensive and accurate information on the actual condition of animals previous to and during population decreases are needed to determine the conditions responsible for the declines.

One of the ways in which population declines are brought about is through emigration. Norwegian lemmings afford the classic example of the operation of this kind of population decrease. It has been suggested that emigration may be due to some sort of diseased condition but no support, so far as I am aware, has been obtained for this speculation. There is, however, a good deal of observational evidence suggesting that abnormal behavior patterns characterize the lemmings at the time of their emigrations. Experiments with locusts have shown that changes in behavior leading to mass movements can be brought about by conditions associated with crowding. These findings suggest the desirability of the experimental approach to the problem of emigration in lemmings and other animals whose populations are periodically reduced by this means. If population density is shown to initiate mass movements resulting in emigration, the problem of periodicity in such cases will then be reduced to that of discovering why the necessary population density is usually attained after the lapse of a fairly definite number of years.

That emigration is not necessarily characteristic of certain animals such as lemmings is indicated by the fact that there is no little evidence of emigration among North American lemmings. Although information is far from adequate, what is available suggest that some other factor is usually responsible for the decline of lemming populations in America. Further evidence that periodic population declines of the same species sometimes result from emigration and sometimes from other causes is afforded by the sharp-tailed grouse. There is evidence that this is one of the species having a nine or ten year periodic fluctuation in numbers but emigrations, at least spectacular ones, occur at much longer intervals.

This brings us back again to the need for more information on what actually happens when a population declines. Does the decrease in numbers result from the failure of reproduction to replace animals suffering normal mortality, from an increase in the death rate, from a combination of the two conditions or from emigration? Research on wildlife cycles is basically a study of what causes the death of animals in nature or of what interferes with their birth, or both. Emigration, of course, results in the death of most of the animals involved in it. Until we have a great deal more knowledge of this sort, explanations of the causes of periodic fluctuations in animal numbers will be largely speculative.

There would therefore appear to be two types of information basic in research on animal cycles. The first is records of the actual changes in the numbers of different kinds of animals from year to year over as wide an area as possible. The second is facts relative to the causes of the death of animals and the reasons for changes in reproduction, if such changes are shown to occur.

There is a need for both individual and institutional effort in biological cycle research. The investigation of diseases and emigration and associated conditions such as the relation of parasites to disease provide many problems suitable for research by an individual scientist. However, many of the phenomena associated with animal cycles occur over such wide areas and involve such relatively long periods of time that their investigation requires the co-operation of so many people and over such periods of time that organization under one or more institutions is necessary.

Examples of co-operative efforts under an institution are afforded by the study of fluctuations in the populations of varying hares and of Arctic animals carried on through questionnaires by the Bureau of Animal Populations at Oxford and by similar studies of a variety of birds and mammals by the Royal Ontario Museum of Zoology at Toronto. A number of reports on snowy owl periodicities resulting from this co-operative study have already appeared. Dr. John P. Calhoun, formerly of Johns Hopkins University, has also been carrying on a census of North American small mammals.

All of these co-operative projects are concerned, so far, largely with actual changes in annual populations. These are valuable; it is hoped that the efforts of these and still other organizations can be continued not only long enough to record variations in the length and amplitude of fluctuations but to demonstrate cycles of twenty-five or fifty years or even longer, if such occur.

However, in addition to co-operative projects concerned with recording changes in annual numbers, there are needed other integrated researches recording changes in environmental factors possibly responsible directly or indirectly for observed changes in populations. These involve meteorological conditions, including light and nutritive qualities of food as well as parasites and disease.

The Journal of Cycle Research can further the effective functioning of research projects by making known to workers in this field the existence of individual and co-operative research projects, by publishing progress reports on their activities and by assisting through publicity the organization and integration of further efforts towards the elucidation of phenomena associated with the periodic fluctuations of particular species.

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Toronto 5, Ontario, Canada.

THE 8-MONTH CYCLE IN SUNSPOT NUMBERS, 1749–1950

by
Gerould T. Lane

Cursory examination of monthly sunspot numbers shows some tendency for minor peaks to come at about 8-month intervals. Are these 8-month waves due to the dynamics of solar activity. Are they due to some rhythmic force acting upon the sun? Or are they purely accidental?

It is obvious that these 8-month waves vary in amplitude. Is this variation a result of the interplay of various cyclic forces about 8-months in length? Is the variation in amplitude purely accidental? Or is there perhaps some other cause?

Are the lengths of these 8-month waves constant or do they vary from time to time? If they vary, is there any regularity in the variation?

Is there any correspondence between the length and timing of the 8-month waves in sunspot numbers and any of the planetary cycles or any of the similar rhythmic cycles which have been observed on earth?

These are some of the questions that come to mind as one notices the 8-month waves in a chart of sunspot numbers.

As a first step toward answering some of these questions, I made a preliminary study of sunspot numbers from 1749 through 1950. The results of this analysis are reported upon in this paper.

One method of studying rhythmic fluctuation consists of manipulating the data in such a way as to leave the rhythm to be tested as undisturbed as possible and at the same time to minimize other rhythms and random variation. Such a process is sometimes called "filtering."

Sunspot numbers from 1749 through 1950 were filtered for an 8-month cycle as follows:

The data used were monthly average relative sunspot numbers.[1] (See Appendix I.)

Each of these data was rounded to the nearest whole number to obtain a series of modified data, called Series A.

The first step of the filtering process was the computation of a 3-month moving average of these rounded data ($\frac{A+B+C}{3}$ or $1/3\,A + 1/3\,B + 1/3\,C$). The series thus obtained was called Series B. It is plotted as the lower curve in charts of cycles 1 to 19 inclusive shown herewith.

The second step in the filtering process was the computation of a 17-month weighted moving average of Series B using the weights ¼,0,0,0,0,0,0,0,½,0,0,0,0,0,0,0,½. The series thus obtained was called Series C.

The third step in the filtering process was the computation of a 9-month weighted moving average of Series C using the weights -¼,0,0,0,½,0,0,0,-¼. The series thus obtained was called Series D.

The fourth and final step in the filtering was the computation of a 25-month weighted moving average of Series D using the weights -¼,0,0,0,0,0,0,0,0,0,0,0,½,0,0,0,0,0,0,0,0,0,0,0,-¼. The series thus obtained was called Series E. It is plotted as the solid line in the upper curves in the charts of cycles 1 to 19 inclusive.

In actual practice, to reduce arithmetic, a 3-month moving total was smoothed by a 25-month weighted moving total with the weights -1,0,0,0,2,0,0,0,-3,0,0,0,4,0,0,0,-3,0,0,0,2,0,0,0,-1.

The result was smoothed by a 25-month

(Text continued on page 121.)

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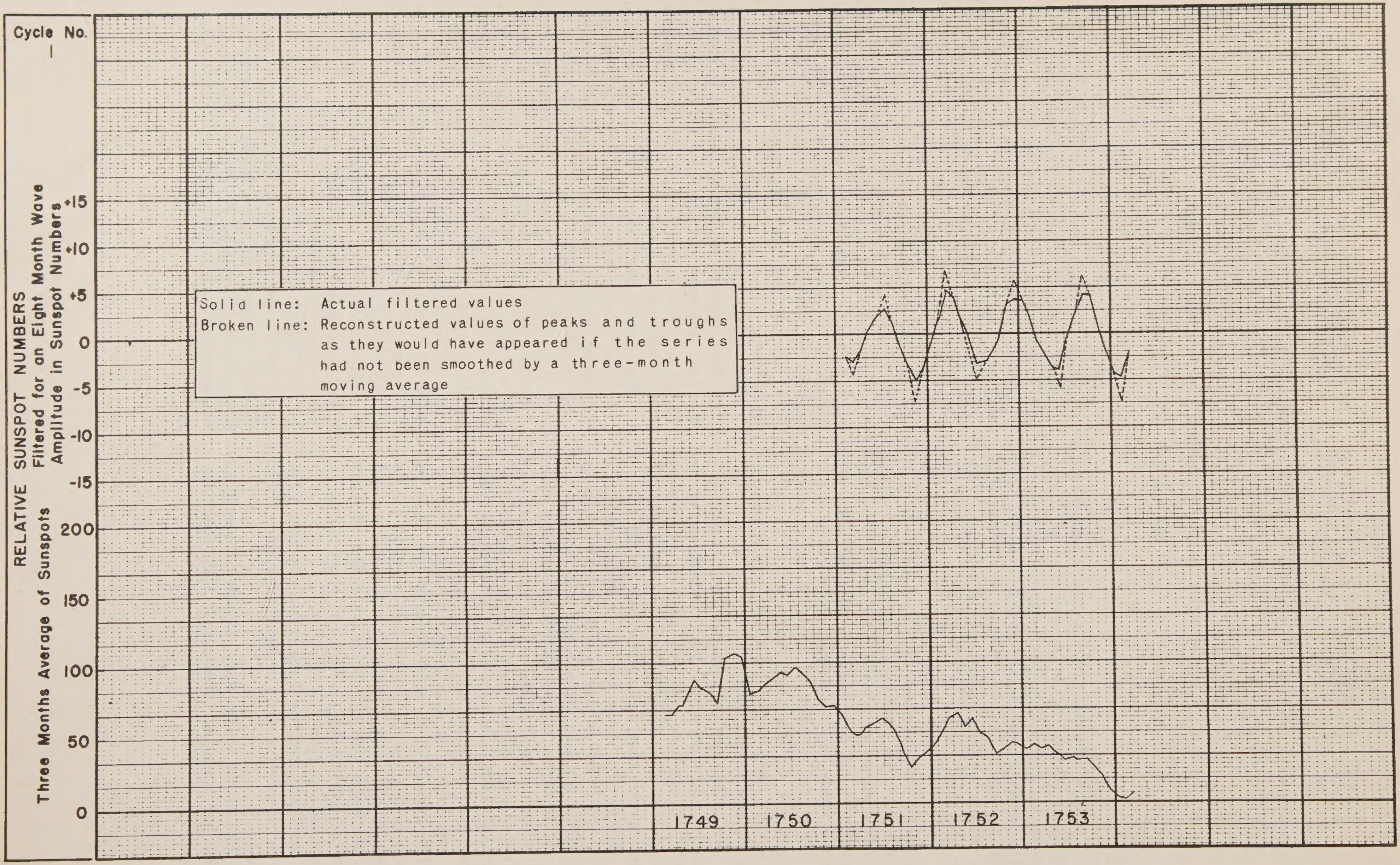
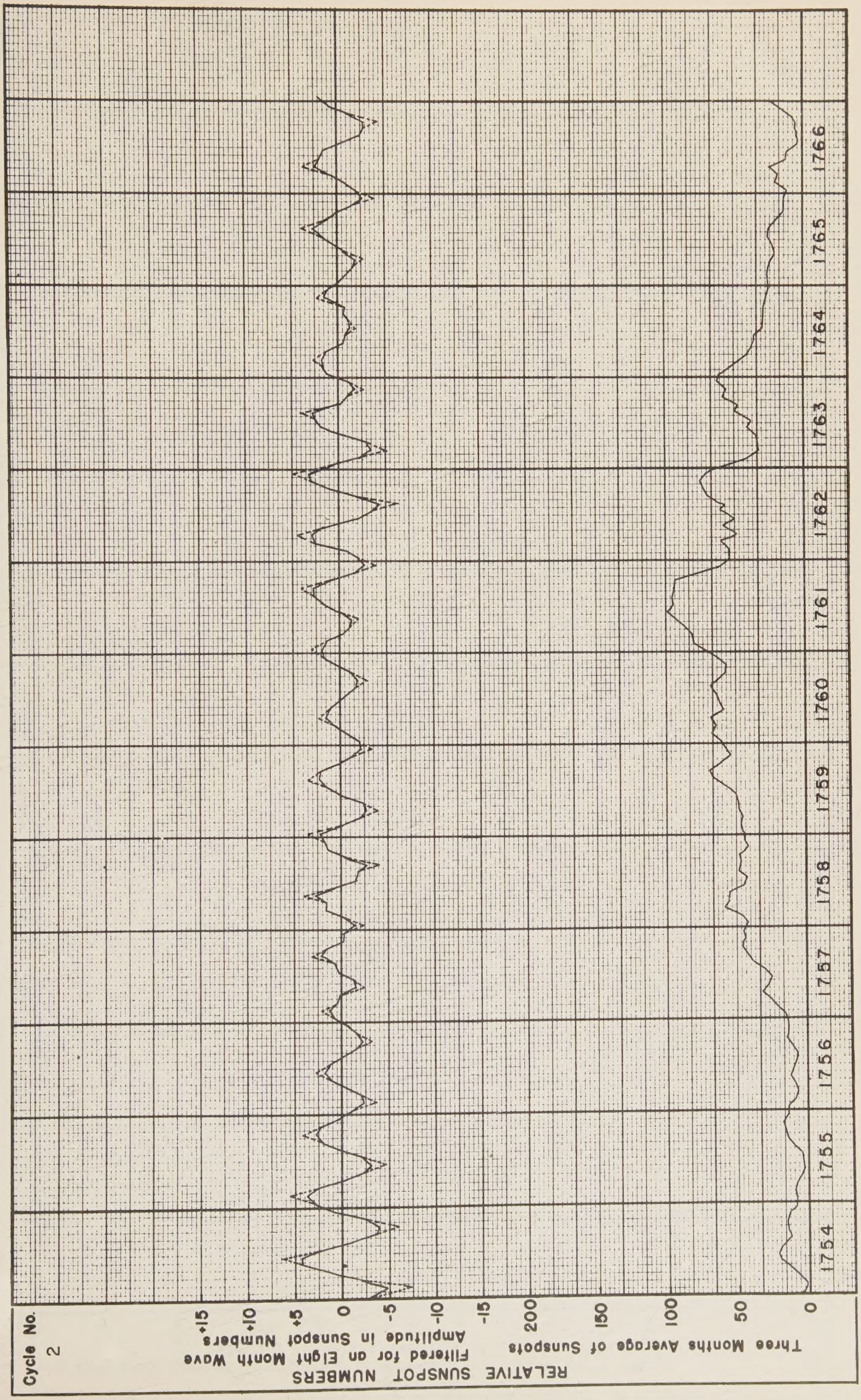
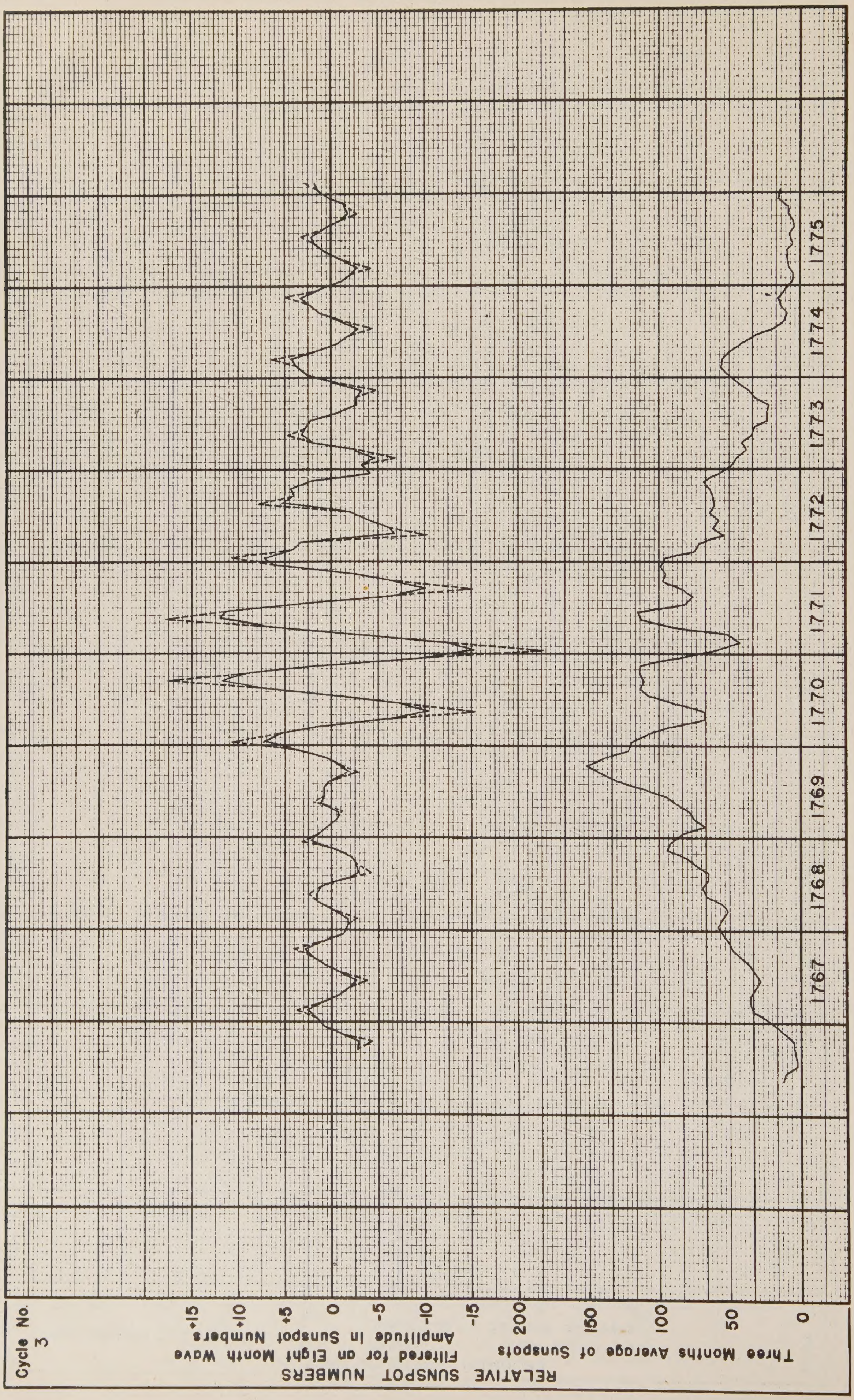
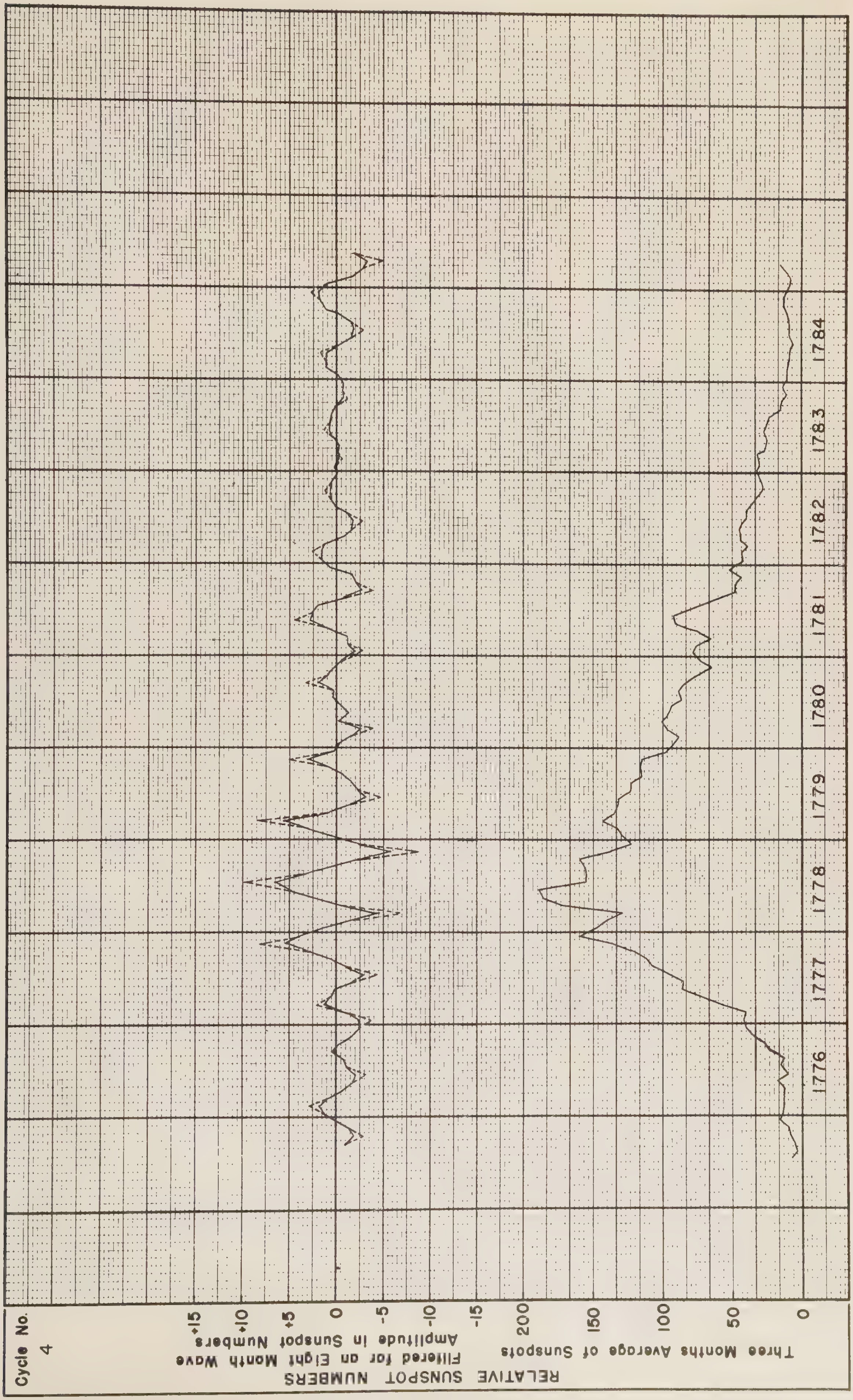
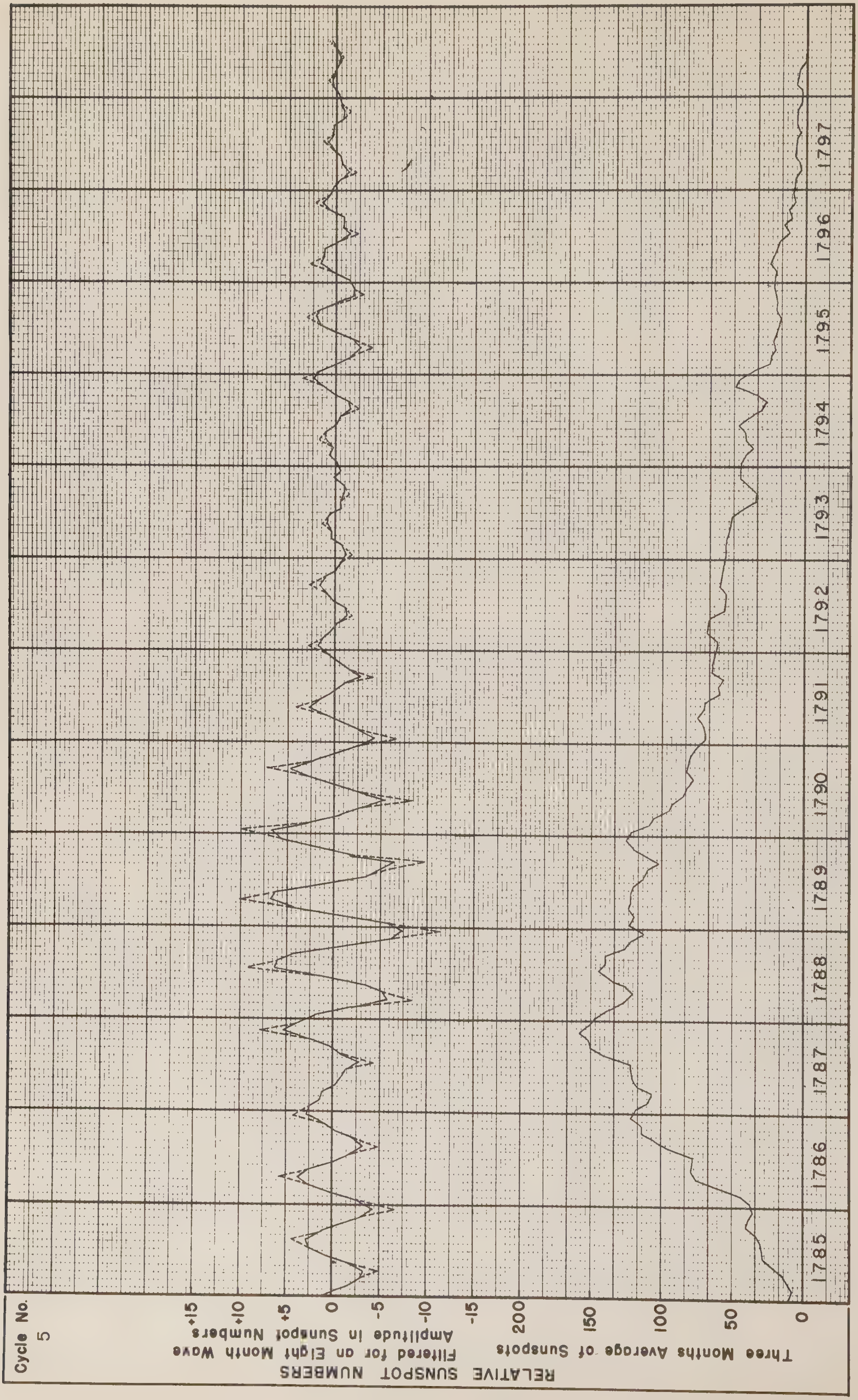
[1] "Solar-Cycle Data for Correlation with Radio Propagation Phenomena," published by Interservice Radio Propagation Laboratory, National Bureau of Standards, Washington, D.C., 1945 and monthly supplements.

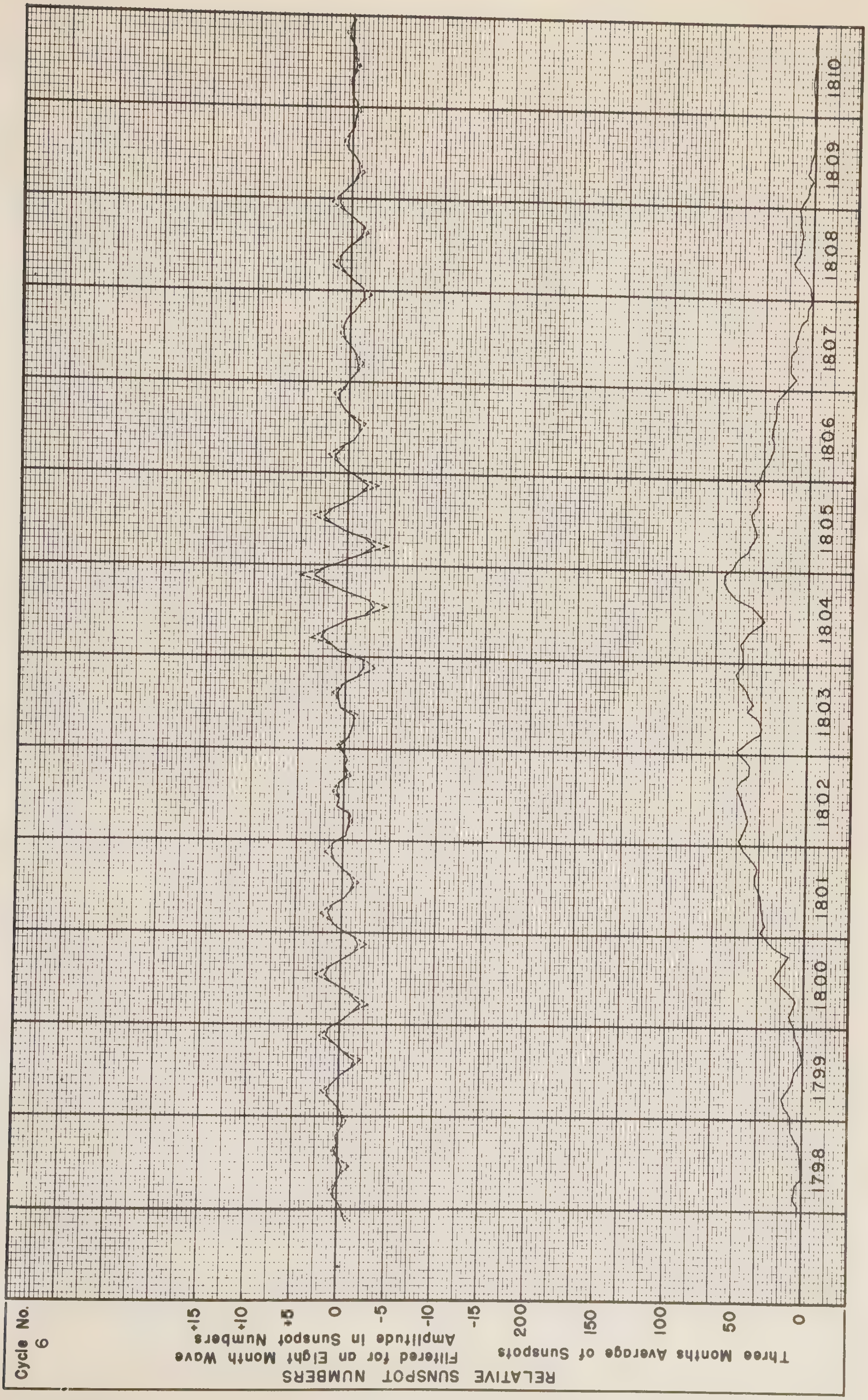

Cycle No.
I
RELATIVE SUNSPOT NUMBERS
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
Solid line: Actual filtered values
Broken line: Reconstructed values of peaks and troughs as they would have appeared if the series had not been smoothed by a three-month moving average
1749
1750
1751
1752
1753


Cycle No.
2
RELATIVE SUNSPOT NUMBERS
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766


Cycle No. 3
RELATIVE SUNSPOT NUMBERS
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1767
1768
1769
1770
1771
1772
1773
1774
1775


Cycle No.
4
RELATIVE SUNSPOT NUMBERS
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1776
1777
1778
1779
1780
1781
1782
1783
1784


Cycle No.
5
RELATIVE SUNSPOT NUMBERS
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797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Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
Three Months Average of Sunspots
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+10
+5
0
-5
-10
-15
200
150
100
50
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1799
1800
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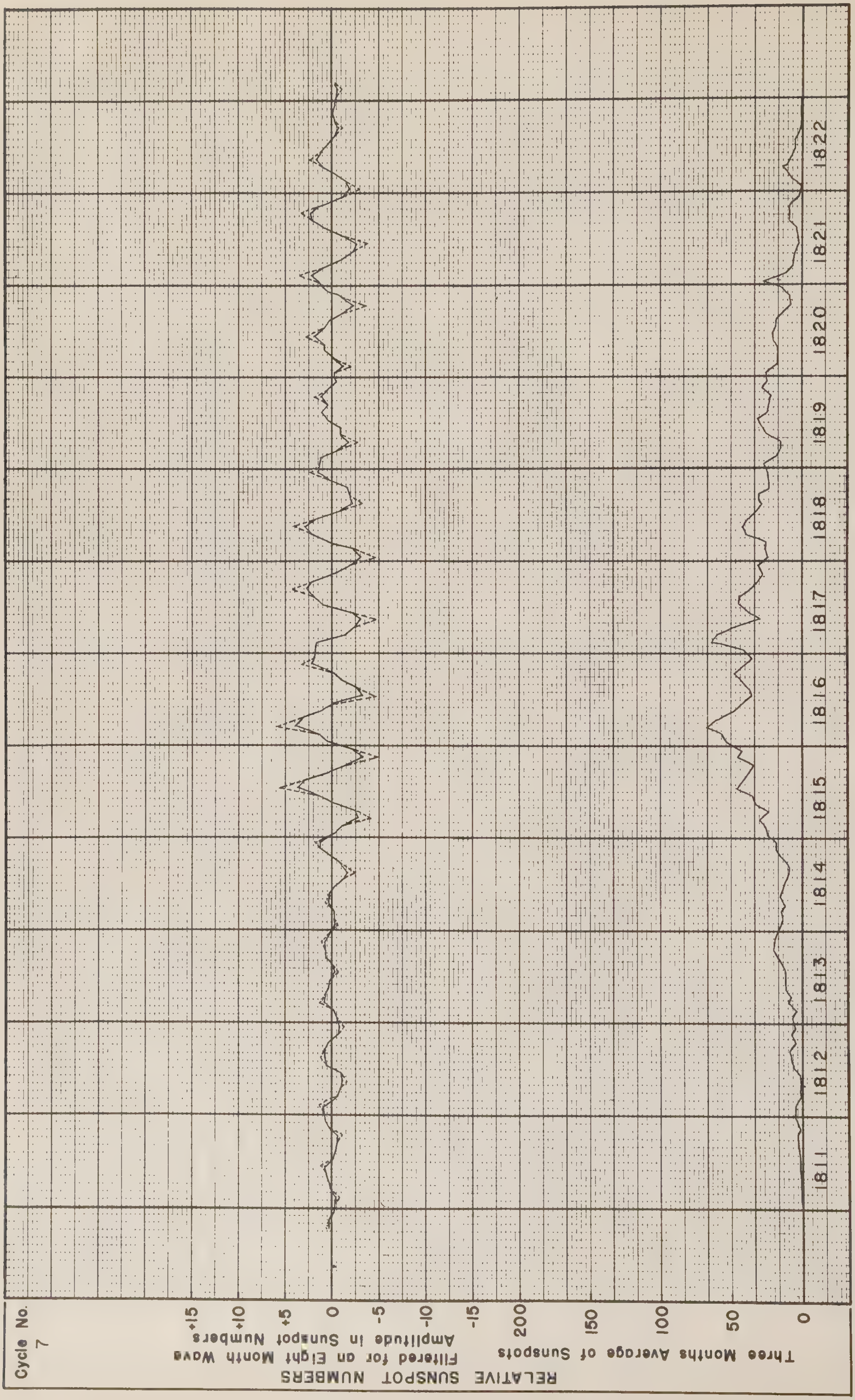
1803
1804
1805
1806
1807
1808
1809
1810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Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
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+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
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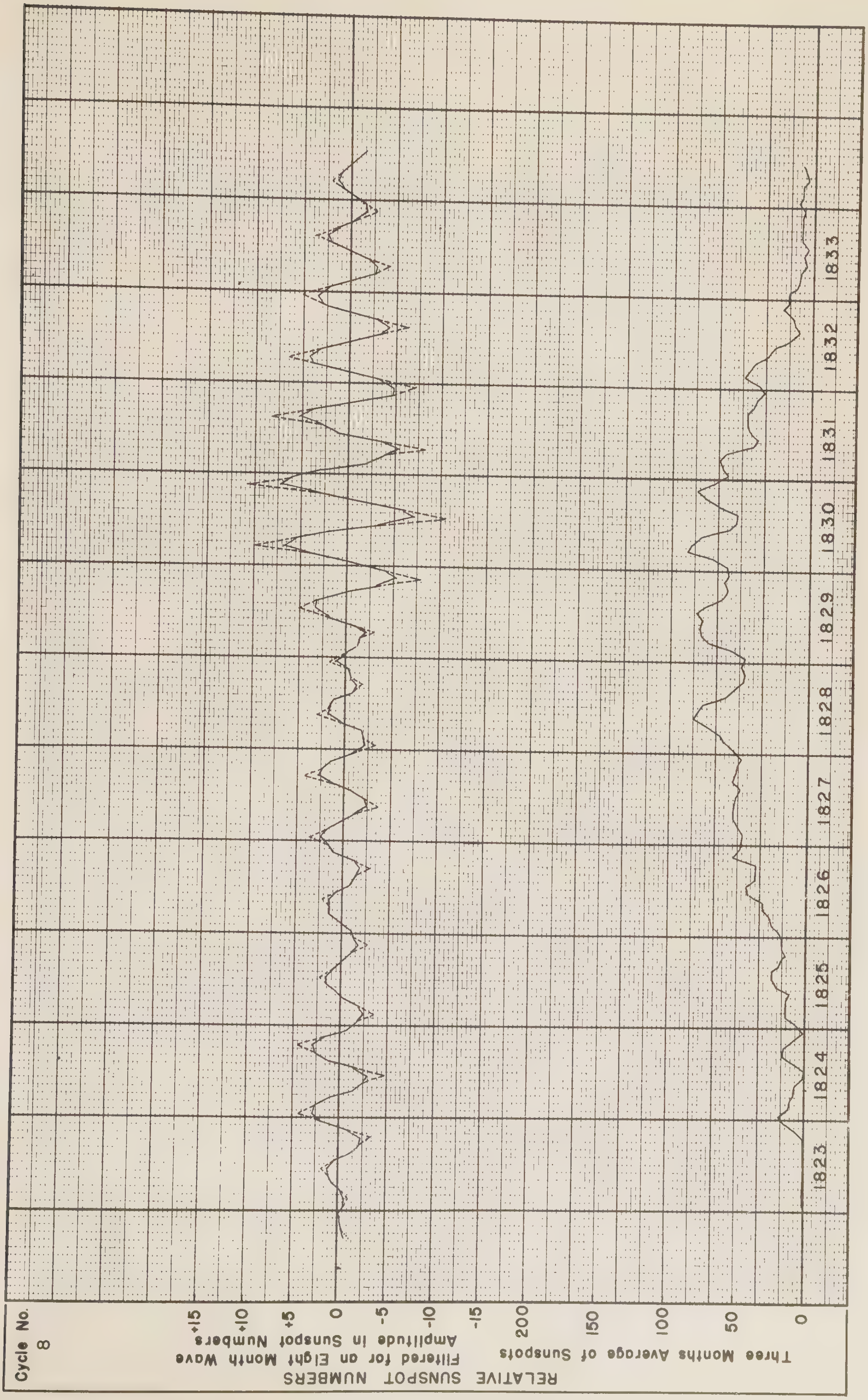
1818
1819
1820
1821
1822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Cycle No. 8
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Amplitude in Sunspot Numbers
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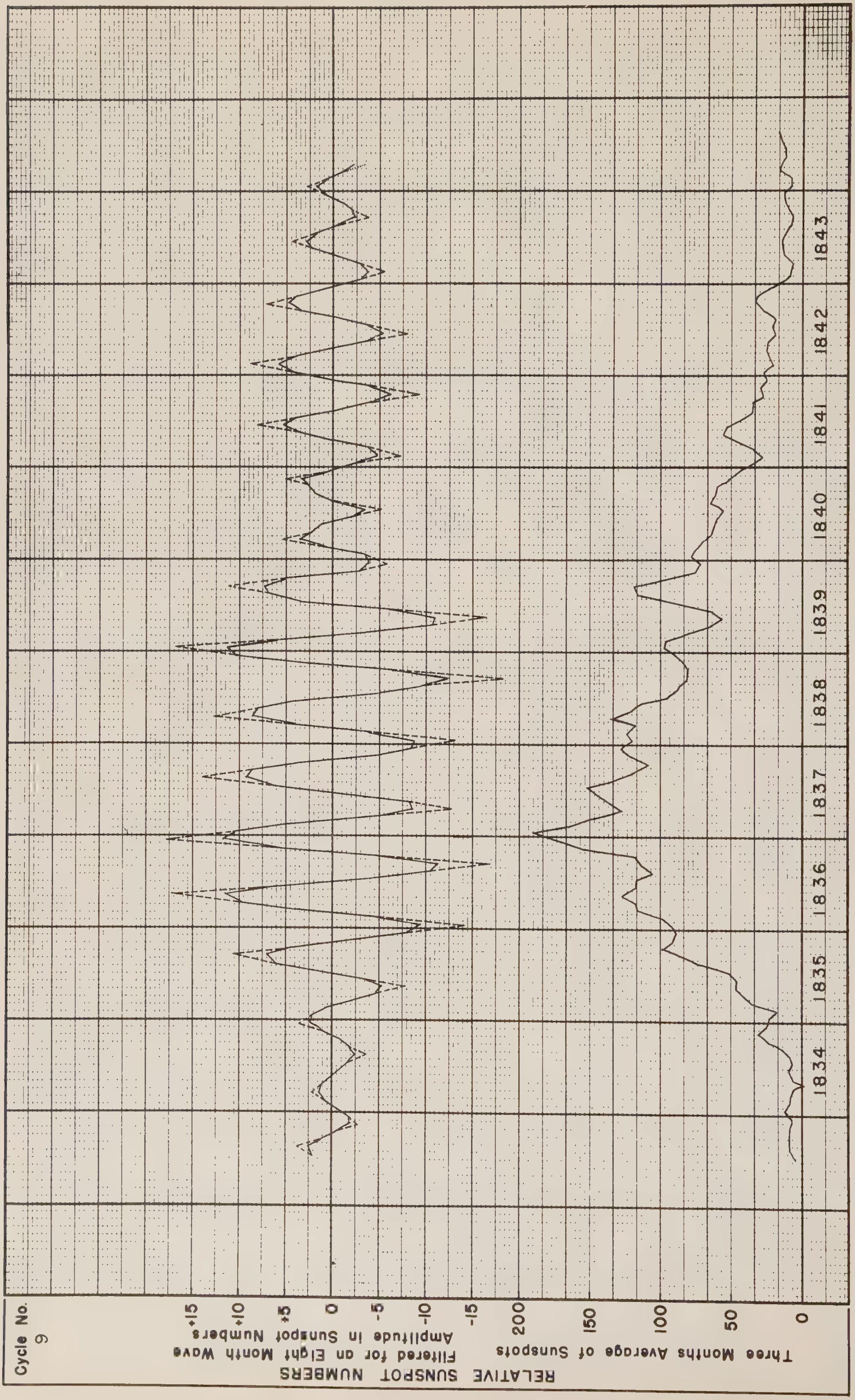
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833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Amplitude in Sunspot Numbers
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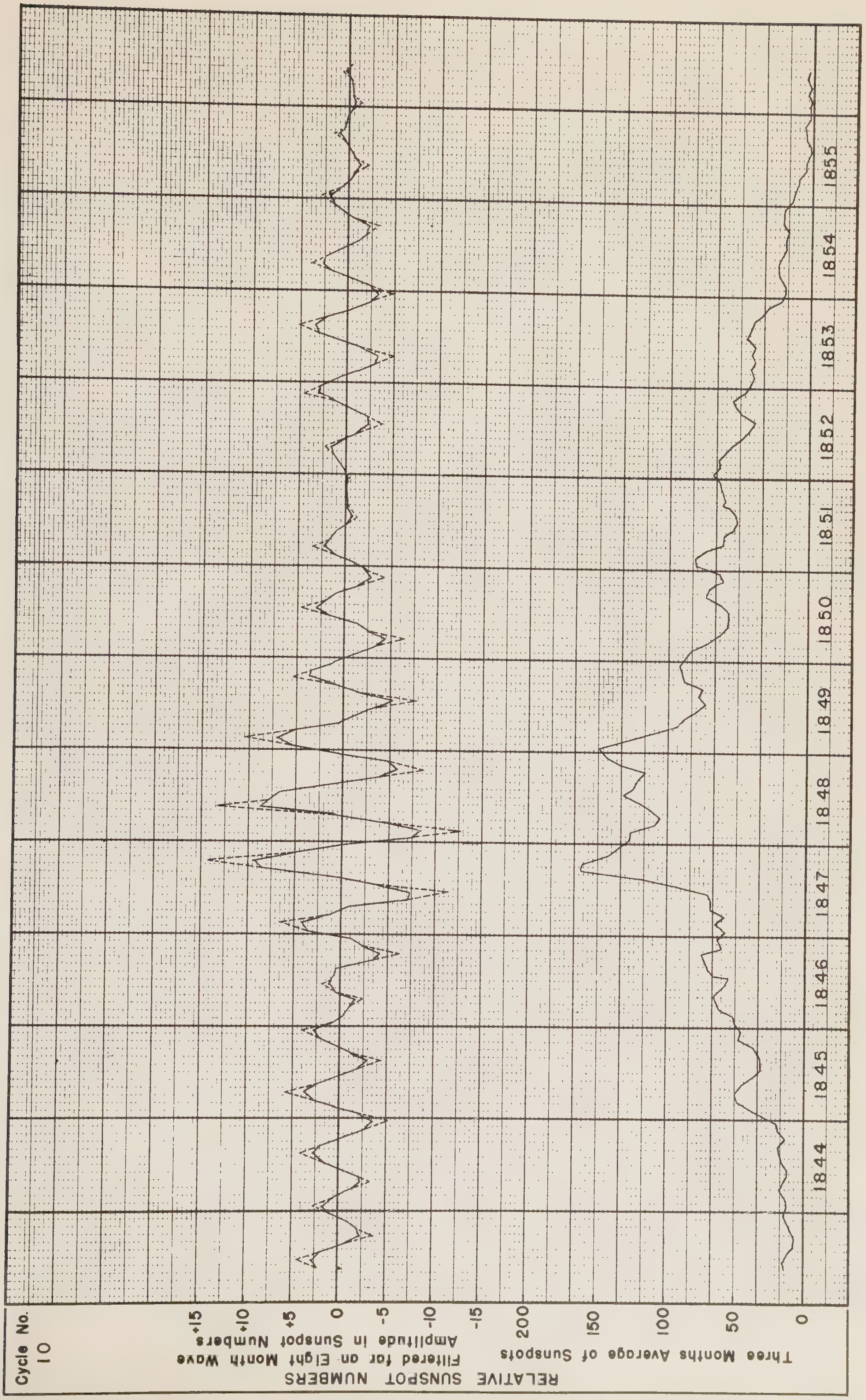
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843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Amplitude in Sunspot Numbers
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+10
+5
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-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
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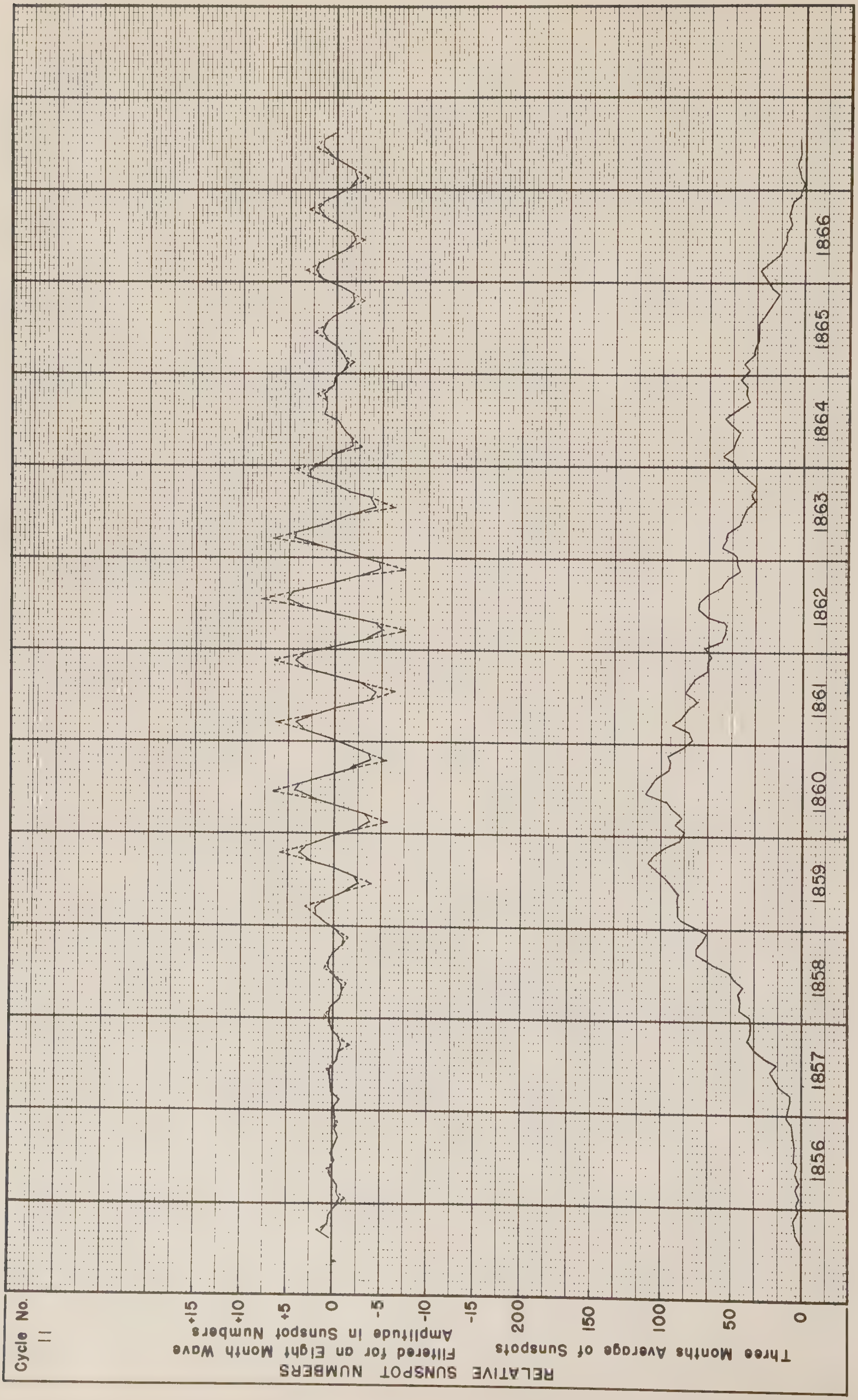
1851
1852
1853
1854
1855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Amplitude in Sunspot Numbers
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+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
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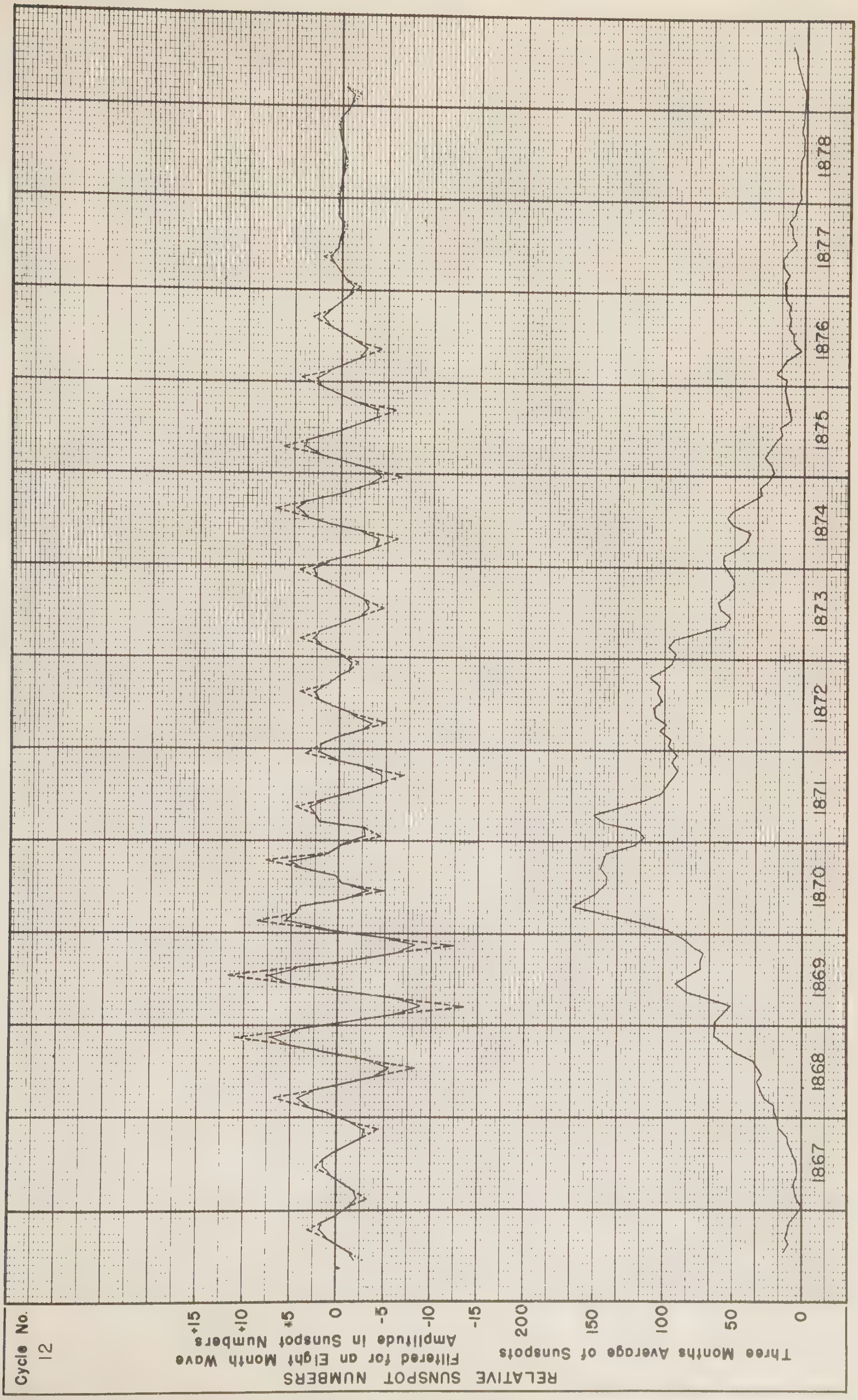
1862
1863
1864
1865
1866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Amplitude in Sunspot Numbers
Three Months Average of Sunspots
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+10
+5
0
-5
-10
-15
200
150
100
50
0
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1868
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1871
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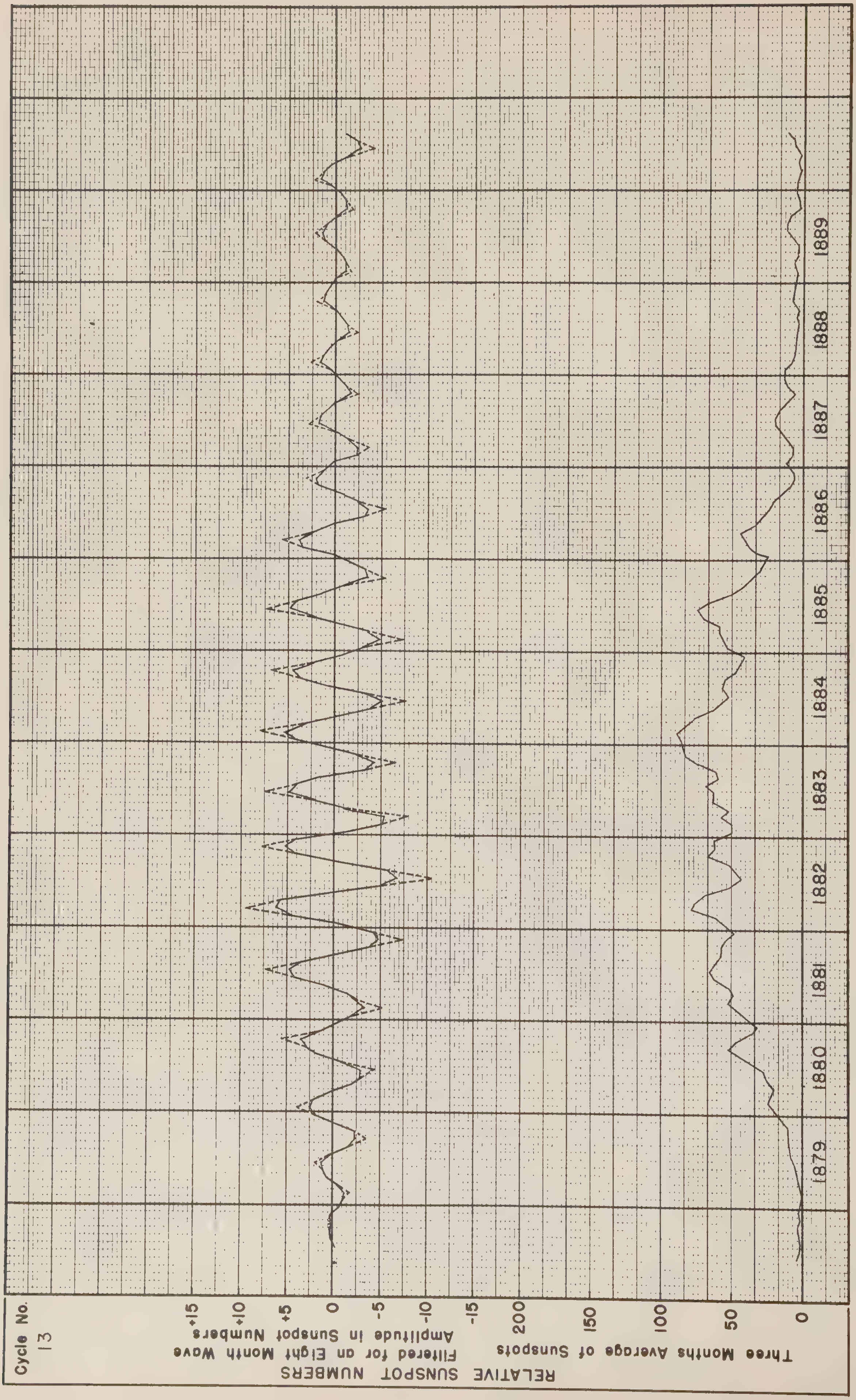
1874
1875
1876
1877
1878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RELATIVE SUNSPOT NUMBERS
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
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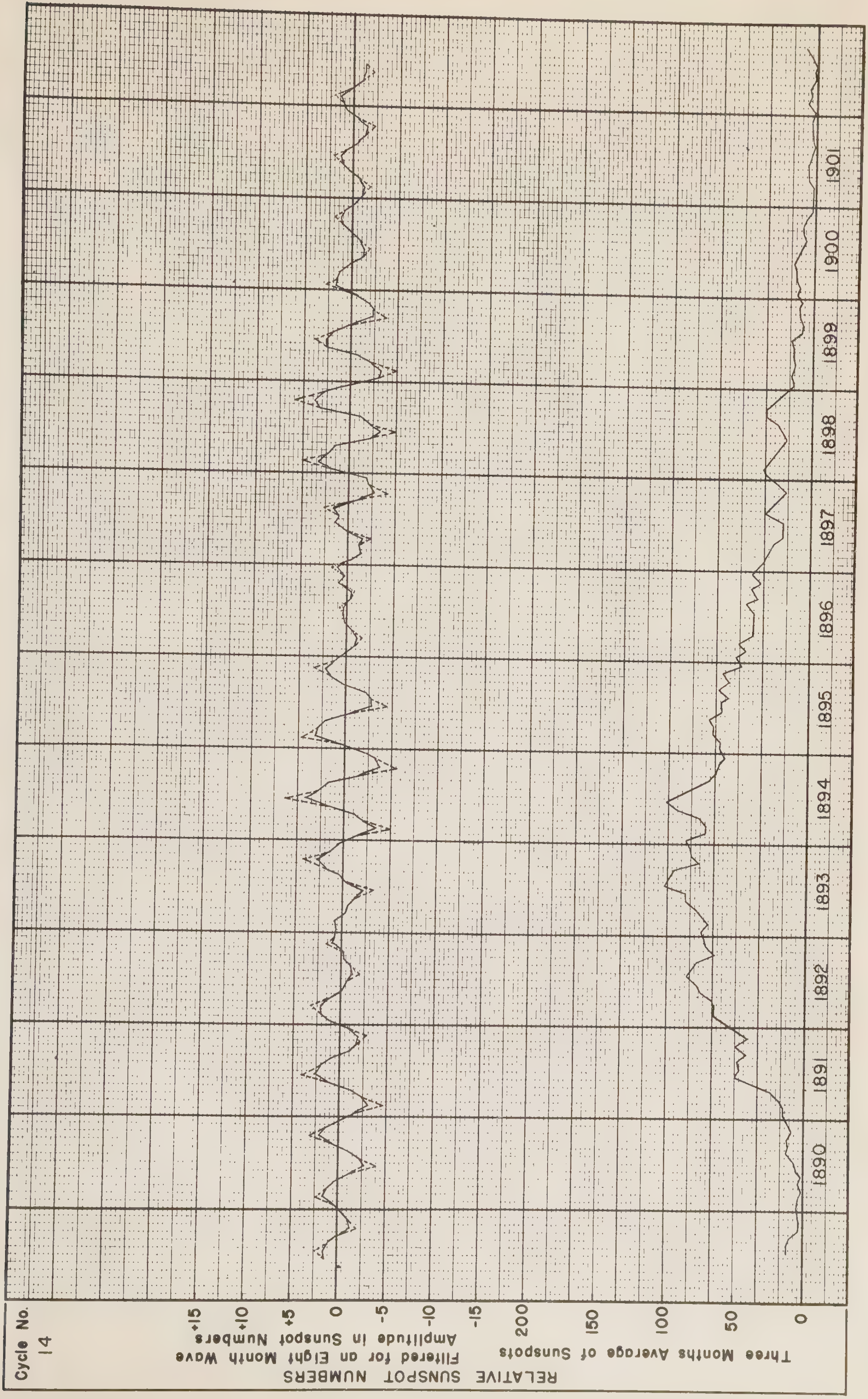
1885
1886
1887
1888
1889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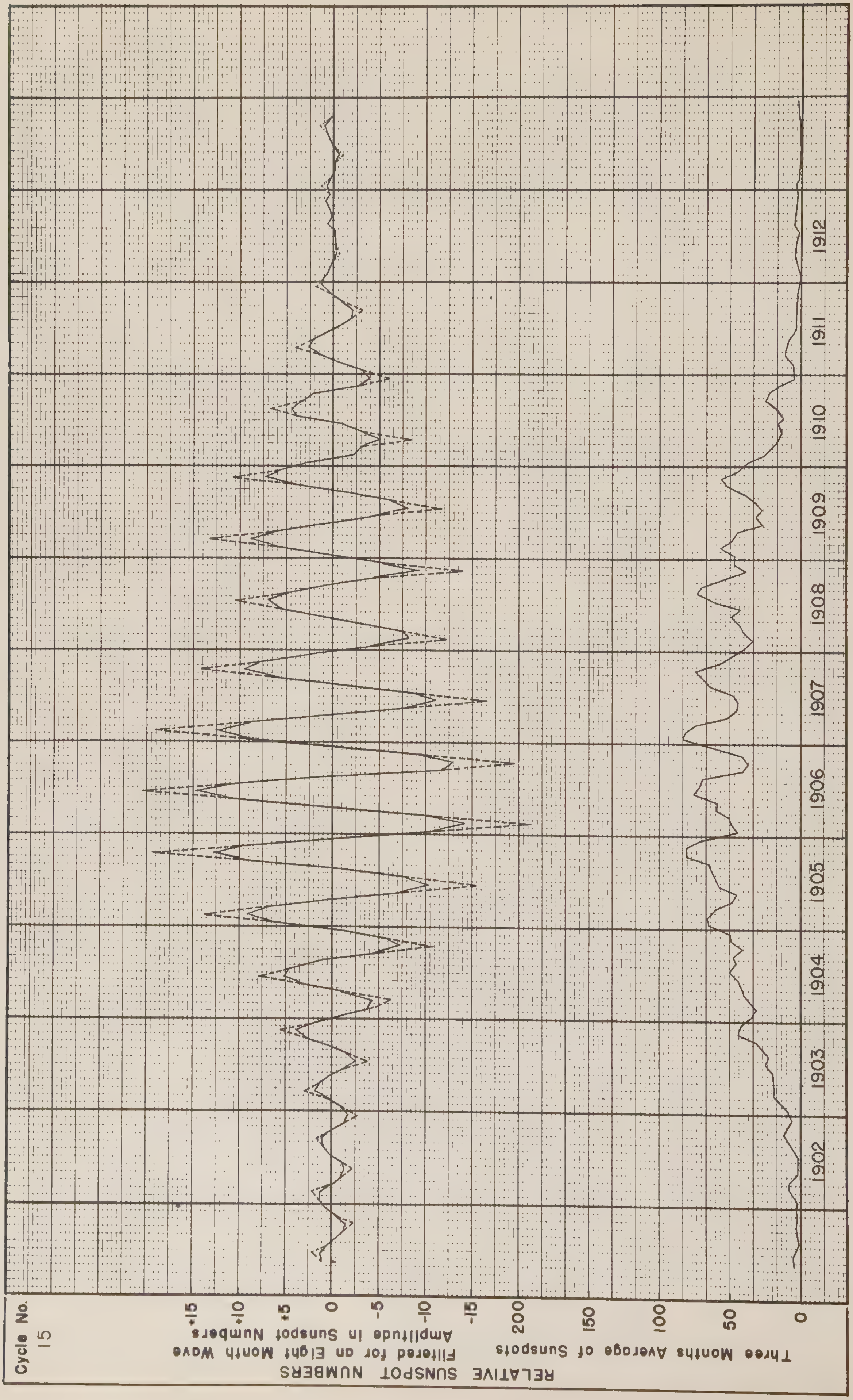
14
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901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+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
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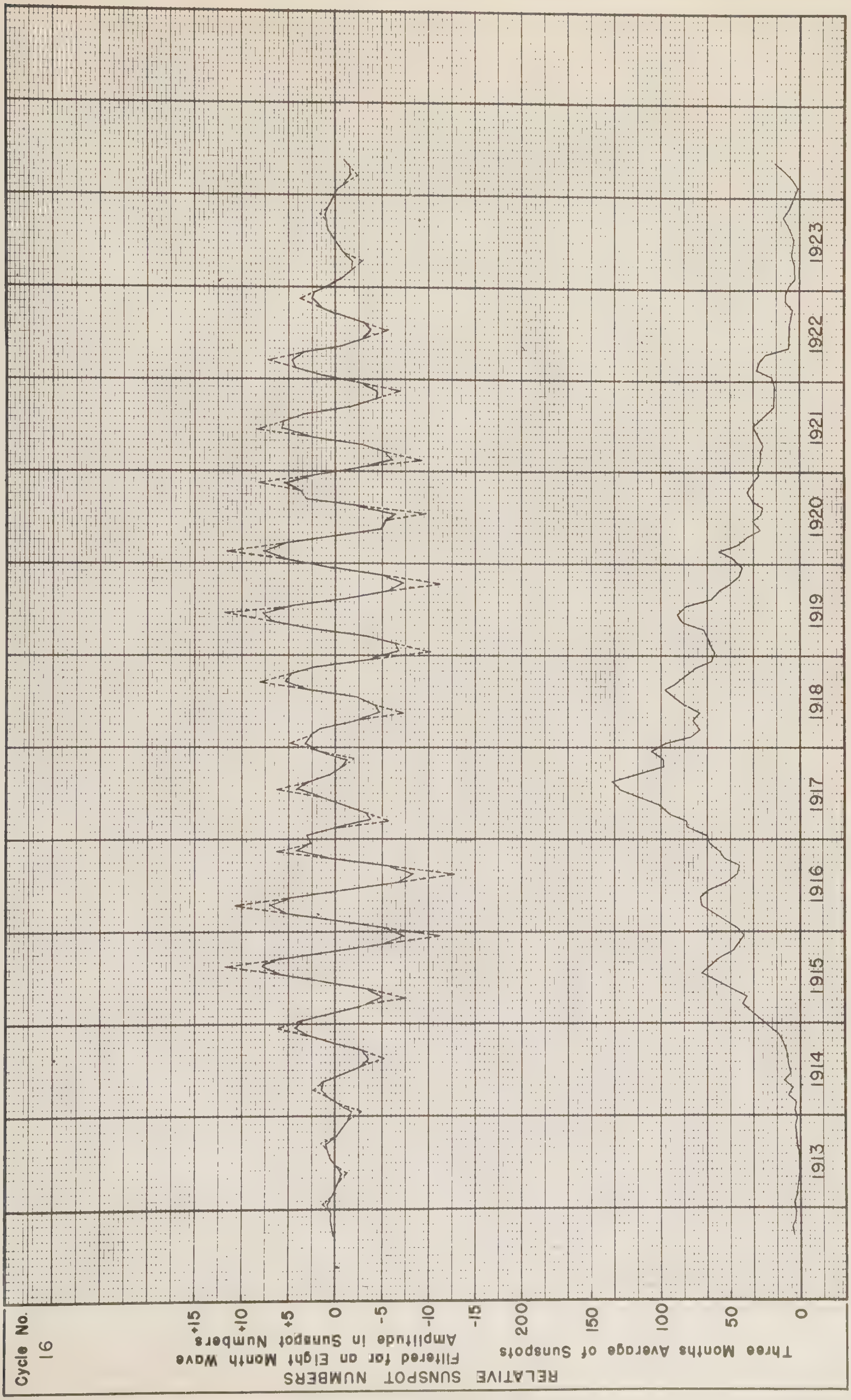
1912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RELATIVE SUNSPOT NUMBERS
Amplitude in Sunspot Numbers
Filtered for an Eight Month Wave
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1913
1914
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1919
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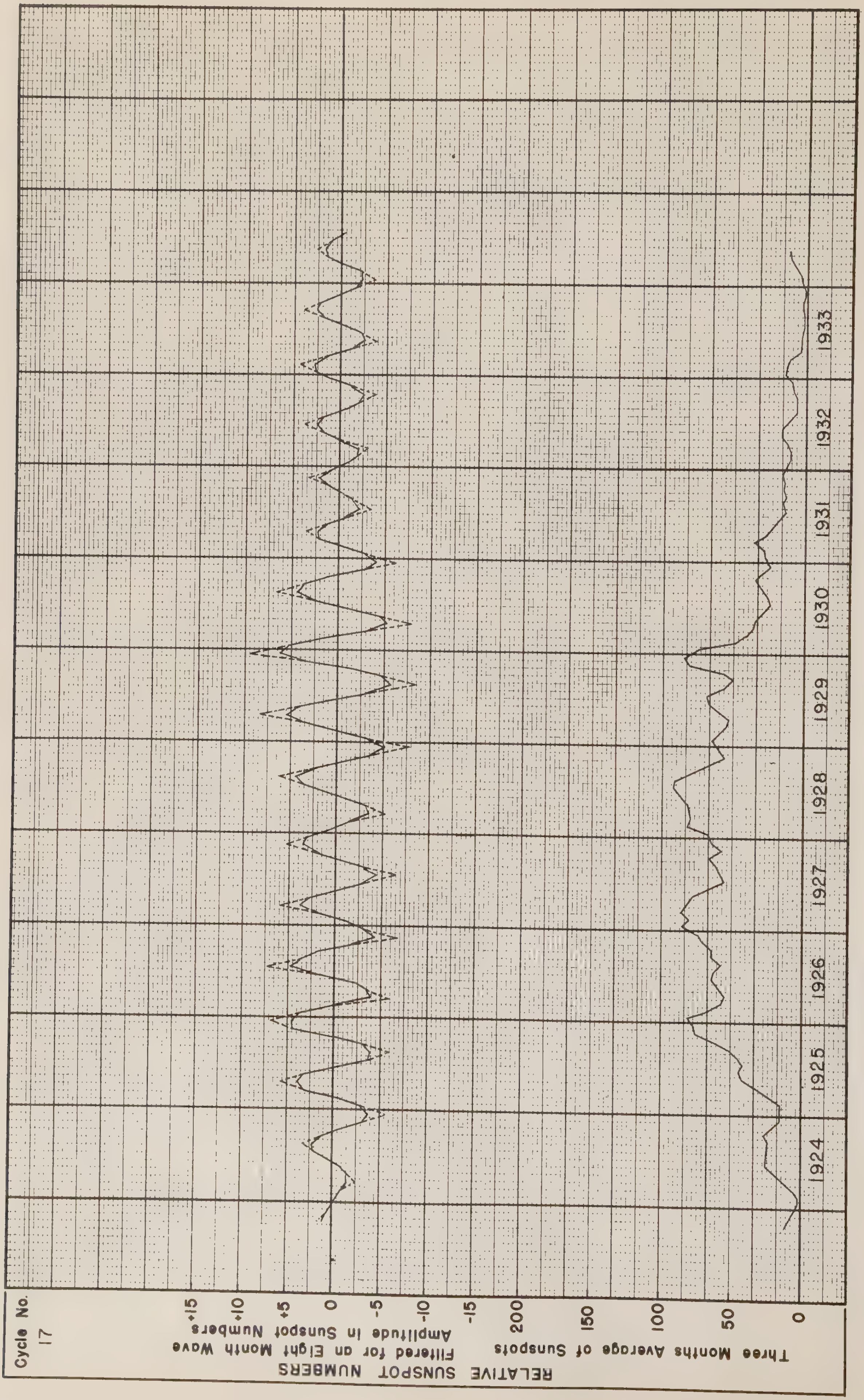
1921
1922
1923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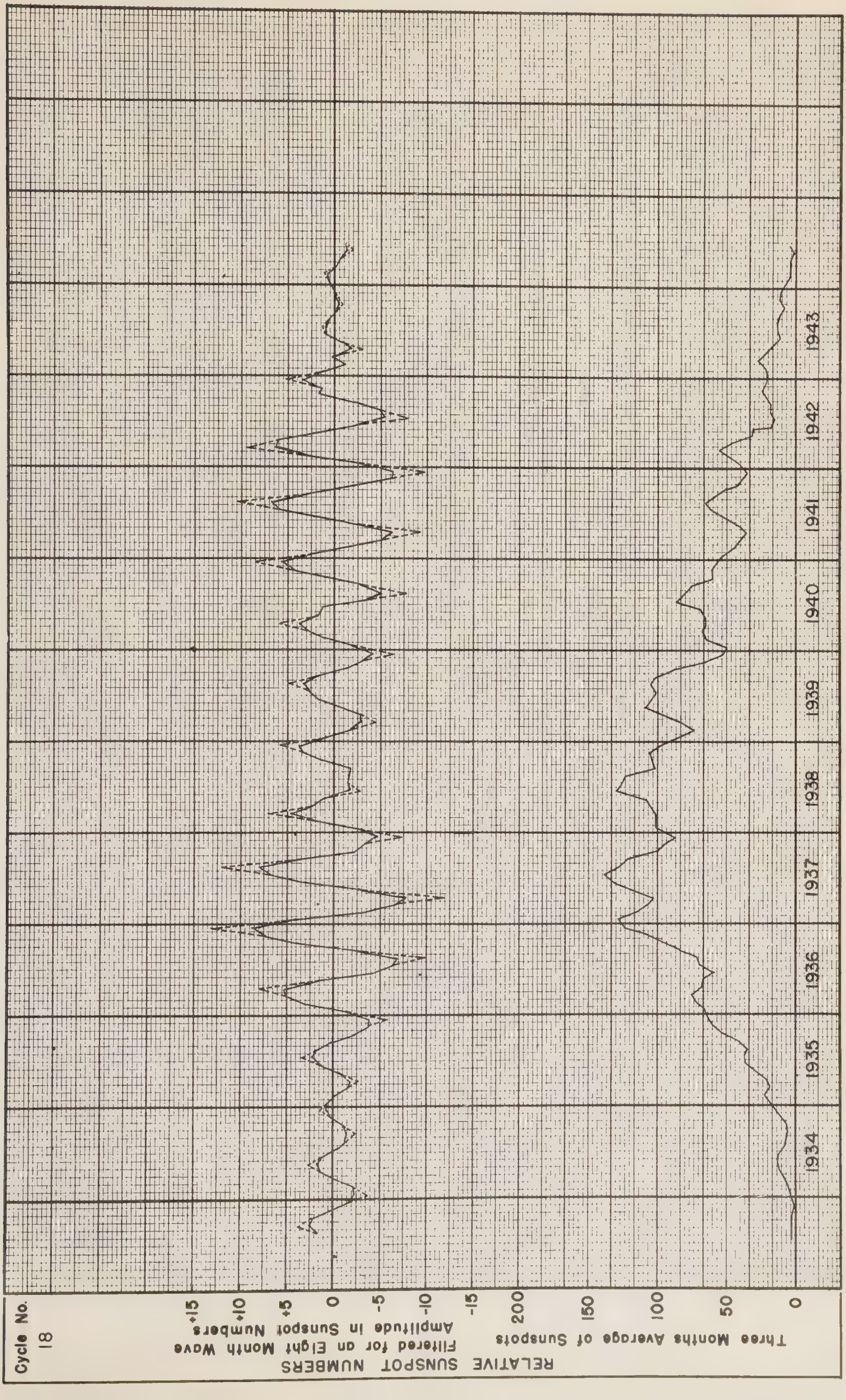
RELATIVE SUNSPOT NUMBERS
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933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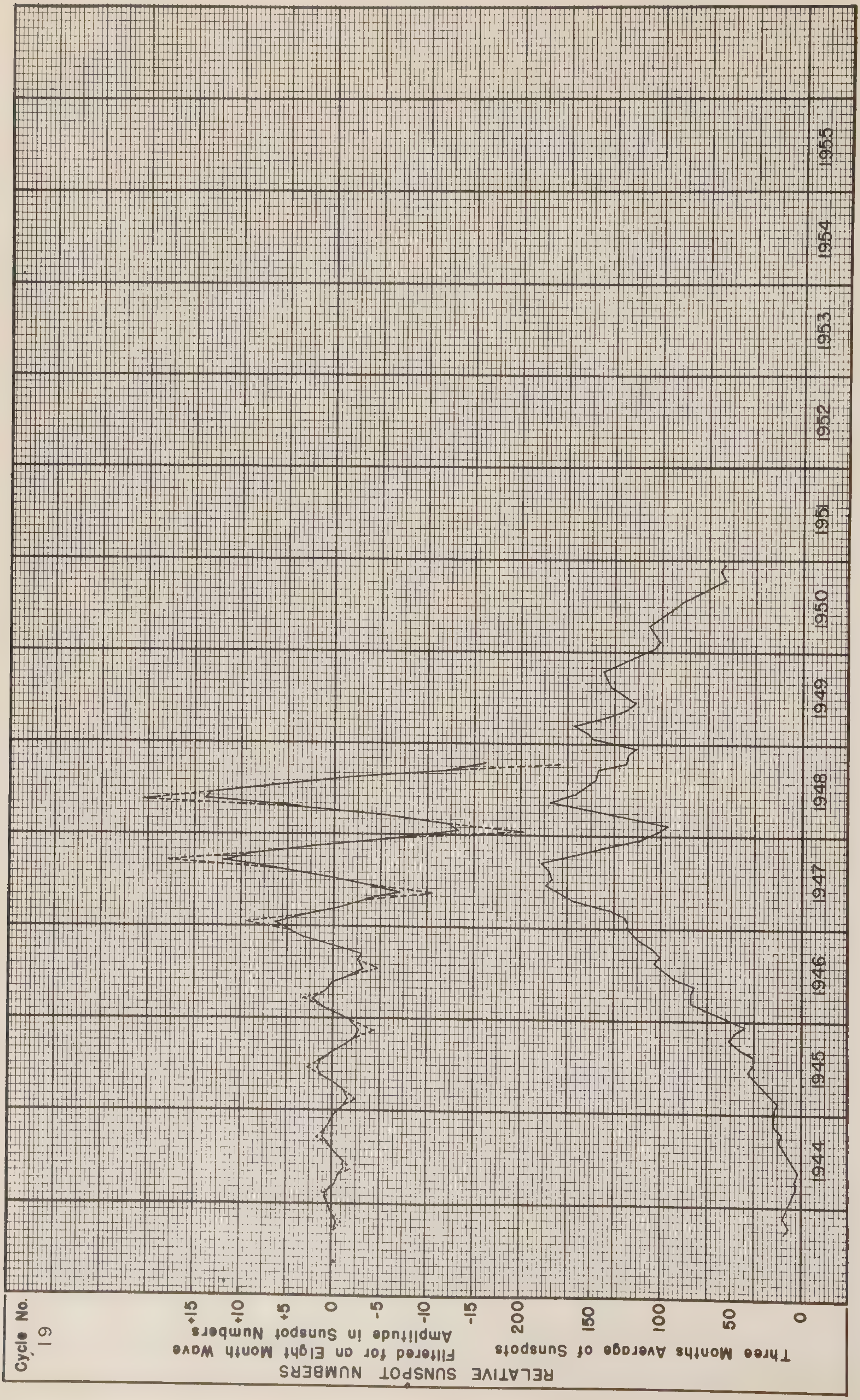
RELATIVE SUNSPOT NUMBERS
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943


Cycle No.
19
RELATIVE SUNSPOT NUMBERS
Filtered for an Eight Month Wave
Amplitude in Sunspot Numbers
+15
+10
+5
0
-5
-10
-15
Three Months Average of Sunspots
200
150
100
50
0
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955

(Continued from page 101.)

weighted moving total with the weights -1,0,0,0,0,0,0,0,0,0,0,0,2,0,0,0,0,0,0,0,0,0,0,0,-1.

Each term of the result was divided by 192. The work was done by I.B.M. machine.

It will be clearer to describe each step separately, however, as if four suc-

TABLE 1

COMPUTATION OF THE FIRST TERM OF THE FINAL RESULT

DATE	COL. A SUNSPOT NUMBERS	COL. B SUNSPOT NUMBERS ROUNDED (SERIES A)	COL. C 3-MONTH MOVING AVERAGE OF THE VALUES IN COLUMN B (WEIGHTS 1/3, 1/3, 1/3) (SERIES B)	COL. D 17-MONTH WEIGHTED MOVING AVERAGE OF THE VALUES IN COL. C (WEIGHTS $\frac{1}{4}$,0,0,0,0,0,0,0,$\frac{1}{2}$,0,0,0,0,0,0,0,$\frac{1}{4}$) (SERIES C)	COL. E 9-MONTH WEIGHTED MOVING AVERAGE OF THE VALUES IN COLUMN D (WEIGHTS -$\frac{1}{4}$,0,0,0,$\frac{1}{2}$,0,0,0,-$\frac{1}{4}$) (SERIES D)	COL. F 25-MONTH WEIGHTED MOV. AV. OF THE VALUES IN COLUMN E (WEIGHTS -$\frac{1}{4}$,0,0,0,0,0,0,0,0,0,0,0,$\frac{1}{2}$,0,0,0,0,0,0,0,0,0,0,0,-$\frac{1}{4}$) (SERIES E)
JAN. 1749	58.0	58				
F.	62.6	63	63.67			
M.	70.0	70	63.00			
A.	55.7	56	70.33			
M.	85.0	85	75.00			
J.	83.5	84	88.00			
J.	94.8	95	81.67			
A.	66.3	66	79.00			
S.	75.9	76	72.67			
O.	75.5	76	103.67	90.67		
N.	158.6	159	106.67	93.09		
D.	85.2	85	105.67	93.67		
JAN. 1750	73.3	73	78.00	79.42		
F.	75.9	76	79.33	80.00	-3.92	
M.	89.2	89	84.33	79.58	-5.17	
A.	88.3	88	89.00	81.58	-4.23	
M.	90.0	90	92.67	80.25	1.06	
J.	100.0	100	91.67	85.00	4.67	
J.	85.4	85	96.00	86.75	6.02	
A.	103.0	103	93.00	86.42	5.46	
S.	91.2	91	86.67	76.84	2.46	
O.	65.7	66	73.33	71.33	.48	
N.	63.3	63	68.00	69.83	- .82	
D.	75.4	75	69.33	69.42	-1.71	
JAN. 1751	70.0	70	63.00	63.59	-2.52	
F.	43.5	44	53.00	55.75	-5.21	-2.46
M.	45.3	45	48.33	56.17	-4.75	
A.	56.4	56	54.00	59.25	-2.27	
M.	60.7	61	56.00	60.42	2.60	
J.	50.7	51	59.33	61.00	6.38	
J.	66.3	66	59.00	61.50	6.63	
A.	59.8	60	50.00	58.17	3.61	
S.	23.5	24	35.67	46.84	-2.71	
O.	23.2	23	25.33	40.75	-7.42	
N.	28.5	29	32.00	40.33	-9.00	
D.	44.0	44	36.00	42.67	-6.79	
JAN. 1752	35.0	35	43.00	44.08	- .94	
F.	50.0	50	52.00	50.17	3.35	
M.	71.0	71	60.00	55.17		
A.	59.3	59	63.33	54.33		
M.	59.7	60	53.00	45.09		
J.	39.6	40	59.33	46.17		
J.	78.4	78	49.00			
A.	29.3	29	44.67			
S.	27.1	27	34.33			
O.	46.6	47	37.33			
N.	37.6	38	41.67			
D.	40.0	40	40.67			
JAN. 1753	44.0	44	38.67			
F.	32.0	32	40.67			
M.	45.7	46				

cessive moving averages had really been computed.

At this point it would probably be in order to explain the arithmetic for the benefit of those who are not familiar with weighted moving averages.

The first term of the final result is worked out in Table 1. The other 2373 terms are computed similarly.

The various moving averages are computed as shown in Tables 2, 3, 4, and 5 respectively.

Each of the four manipulations described above has its own effect upon each

TABLE 2.

Computation of the first term of the 3-month moving average. 1/3A + 1/3B + 1/3C posted at position B.

Symbol	Date	Col. A Series A	Col. B Weights	Col. C Series A times weights	Col. D Sum of the three values in Column C
A	Jan. 1749	58	1/3	19 1/3	
B	F.	63	1/3	21	63.67
C	M.	70	1/3	23 1/3	

TABLE 3.

Computation of the 17-month weighted moving average
¼A + 0B + 0C + 0D + 0E + 0F + 0G + 0H + ½I + 0J + 0K + 0L + 0M + 0N + 0O + 0P + ¼Q
posted at position I.

Symbol	Date	Col. A Series B	Col. B Weights	Col. C Series B times weights	Col. D Sum of the 17 values in Column C (Series C)
A	Feb. 1749	63.67	¼	15.92	
B	M.	63.00	0	0	
C	A.	70.33	0	0	
D	M.	75.00	0	0	
E	J.	88.00	0	0	
F	J.	81.67	0	0	
G	A.	79.00	0	0	
H	S.	72.67	0	0	
I	O.	103.67	½	51.83	90.67
J	N.	106.67	0	0	
K	D.	105.67	0	0	
L	Jan. 1750	78.00	0	0	
M	F.	79.33	0	0	
N	M.	84.33	0	0	
O	A.	89.00	0	0	
P	M.	92.67	0	0	
Q	J.	91.67	¼	22.92	

TABLE 4.

Computation of the 9-month weighted moving average
-¼A + 0B + 0C + 0D + ½E + 0F + 0G + 0H + -¼I posted at position E.

Symbol	Date	Col. A Series C	Col. B Weights	Col. C Series C times weights	Col. D Sum of the 9 values in Column C (Series D)
A	Oct. 1749	90.67	-¼	-22.67	
B	N.	93.09	0	0	
C	D.	93.67	0	0	
D	Jan. 1750	79.42	0	0	
E	F.	80.00	½	40.00	-3.92
F	M.	79.58	0	0	
G	A.	81.58	0	0	
H	M.	80.25	0	0	
I	J.	85.00	¼	-21.25	

TABLE 5.
Computation of the 25-Month Weighted Moving Average
$-\frac{1}{4}A + 0B + 0C + 0D + 0E + 0F + 0G + 0H + 0I + 0J + 0K + 0L + \frac{1}{2}M + 0N + 0O + 0P + 0Q + 0R + 0S + 0T + 0U + 0V + 0W + 0X + -\frac{1}{4}Y$ posted at position M.

		Col. A	Col. B	Col. C	Col. D
Symbol	Date	Series D	Weights	Series D times weights	Sum of the 25 values in Column C (Series E)
A	Feb. 1750	-3.92	$-\frac{1}{4}$	-.98	
B	M.	-5.17	0	0	
C	A.	-4.23	0	0	
D	M.	1.06	0	0	
E	J.	4.67	0	0	
F	J.	10.69	0	0	
G	A.	5.46	0	0	
H	S.	2.46	0	0	
I	O.	.48	0	0	
J	N.	-.82	0	0	
K	D.	-1.71	0	0	
L	Jan. 1751	-2.52	0	0	
M	F.	-5.21	$\frac{1}{2}$	-2.60	-2.46
N	M.	-4.75	0	0	
O	A.	-2.27	0	0	
P	M.	2.60	0	0	
Q	J.	7.96	0	0	
R	J.	6.63	0	0	
S	A.	3.61	0	0	
T	S.	-2.71	0	0	
U	O.	-7.42	0	0	
V	N.	-9.00	0	0	
W	D.	-6.79	0	0	
X	Jan. 1752	-.94	0	0	
Y	F.	3.35	$-\frac{1}{4}$	-.84	

periodicity which may be present in the series. Each manipulation also has an effect upon random fluctuations that may be present in the series.

Except for the three-month moving average, the manipulations have been selected so as (a) to leave any regular symmetrical 8-month wave completely undisturbed, (b) to disturb as little as possible any periodicities in the immediate neighborhood of 8 months in length, and (a) to minimize trend and longer and shorter periodicities.

The three-month moving average has the following effects:

It greatly lowers the amplitude and reverses the phase of any symmetrical two month periodicity.

It eliminates any three-month periodicity.

It changes the shape and reduces the amplitude of any periodicity longer than three months but to an increasingly less extent as the periodicity gets longer and longer. See Diagram A.

The amplitude of a symmetrical periodicity of zigzag shape and 8 months in length is reduced by 1/3.[2]

The effect of each of the weighted moving averages upon various periodicities is as follows:

The 17-month weighted moving average has the following effect: Leaves the full amplitude of an eight month cycle and all harmonics of 8 months: Reduces to zero the amplitude of a sixteen month cycle and all odd harmonics of 16 months: all other cycles are reduced in amplitude as illustrated in Diagram B.

The 9-month weighted moving average has the following effect: Leaves the full amplitude of an 8 month cycle and all odd harmonics of 8 months: Reduces to zero the amplitude of a 4 month cycle and all other even harmonics of 8 months: All other cycles are reduced in amplitude as illustrated in Diagram C.

The effect of the 9-month weighted moving average is to eliminate any trend increasing or decreasing by constant amounts as shown in Tables 6 and 7.

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[2] See Technical Bulletin No. 4 of the Foundation for the Study of Cycles, New York, New York: **Cycle Analysis--The Moving Average**, by Edward R. Dewey, 1950.

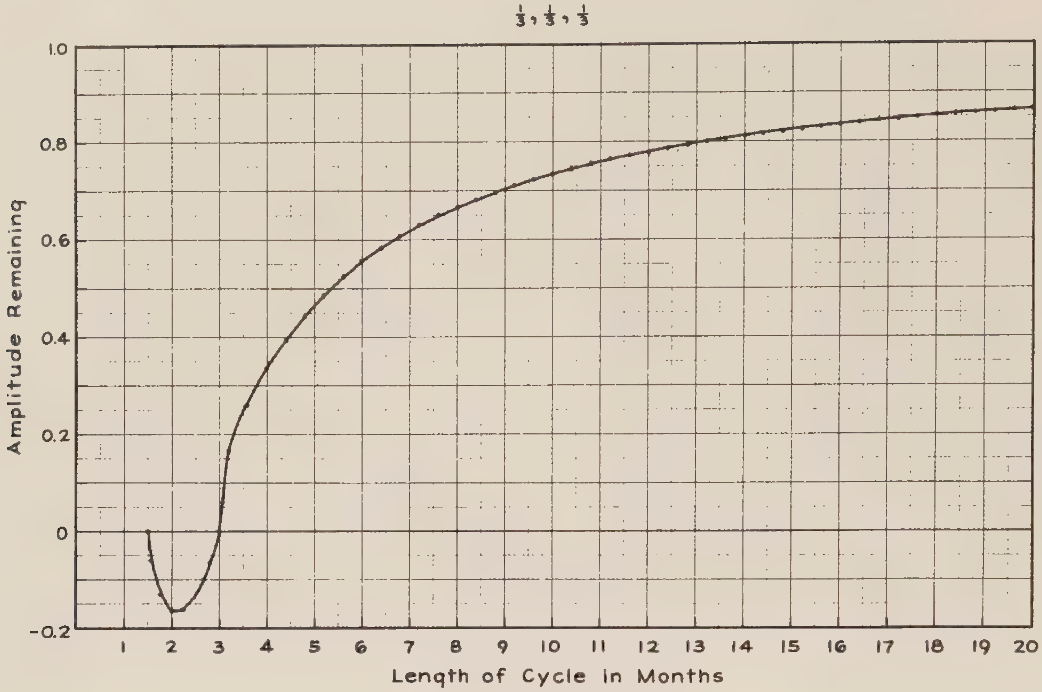

Diagram A

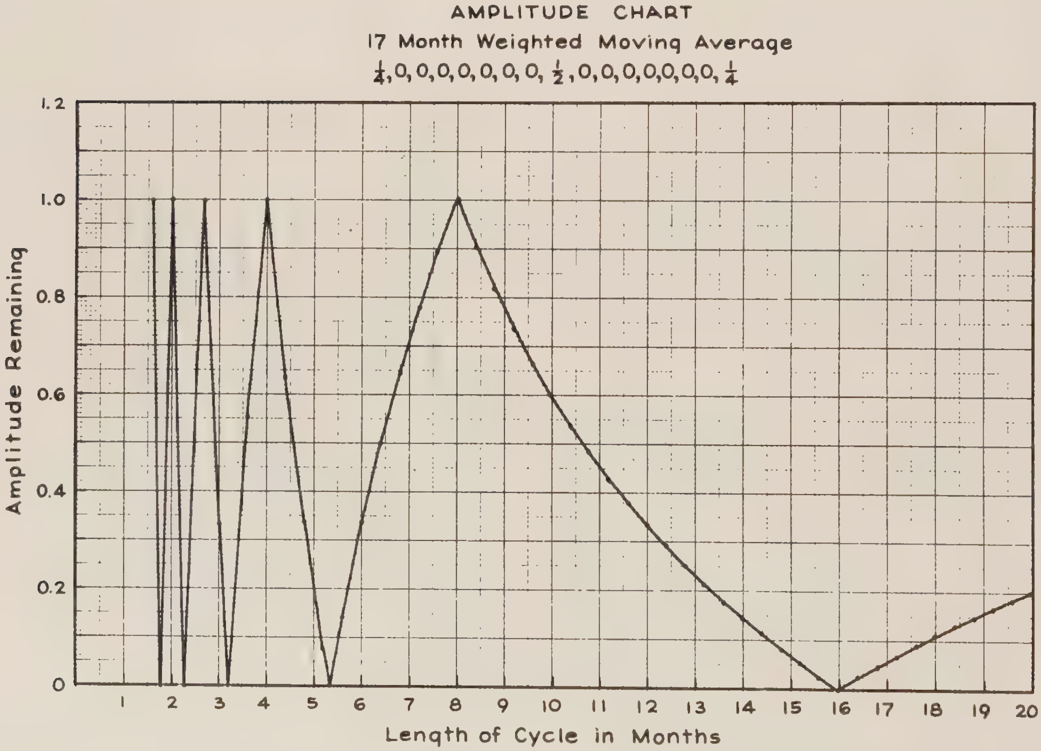

Diagram B

TABLE 6.

THE EFFECT OF A 9-MONTH WEIGHTED MOVING AVERAGE WITH WEIGHTS OF -¼,0,0,0,½,0,0,0,-¼ UPON A TREND INCREASING BY UNIFORM INCREMENTS.

COL. A	COL. B	COL. C
MONTH	TREND	9-MONTH WEIGHTED MOVING AVERAGE OF COLUMN B USING WEIGHTS -¼, 0,0,0,½,0,0,0,-¼
JAN. 1749	1	
F.	2	
M.	3	
A.	4	
M.	5	0
J.	6	0
J.	7	0
A.	8	0
S.	9	0
O.	10	0
N.	11	0
D.	12	0
JAN. 1750	13	
F.	14	
M.	15	
A.	16	

TABLE 7

THE EFFECT OF A 9-MONTH WEIGHTED MOVING AVERAGE WITH WEIGHTS OF -¼,0,0,0,½,0,0,0,-¼ UPON A TREND DECREASING BY UNIFORM INCREMENTS.

COL. A	COL. B	COL. C
MONTH	TREND	9-MONTH WEIGHTED MOVING AVERAGE OF COLUMN B USING WEIGHTS -¼ 0,0,0,½,0,0,0,-¼
JAN. 1749	16	
F.	15	
M.	14	
A.	13	
M.	12	0
J.	11	0
J.	10	0
A.	9	0
S.	8	0
O.	7	0
N.	6	0
D.	5	0
JAN. 1750	4	
F.	3	
M.	2	
A.	1	

AMPLITUDE CHART

9 Month Weighted Moving Average

-¼,0,0,0,½,0,0,0,-¼

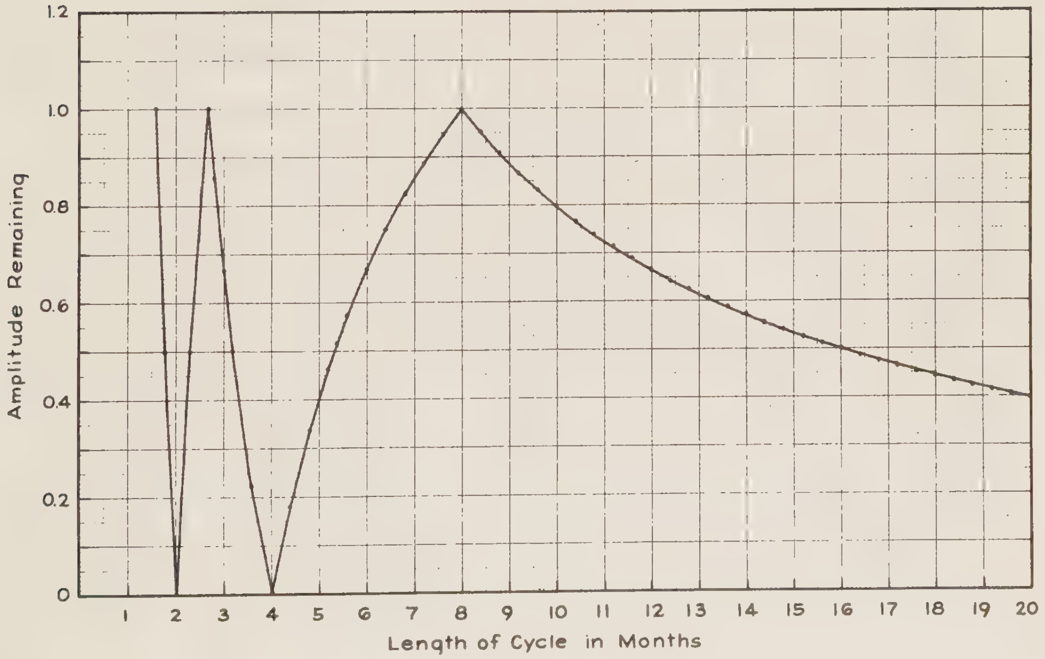

Diagram C

AMPLITUDE CHART

25 Month Weighted Moving Average

$-\frac{1}{4}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, \frac{1}{2}, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, -\frac{1}{4}$

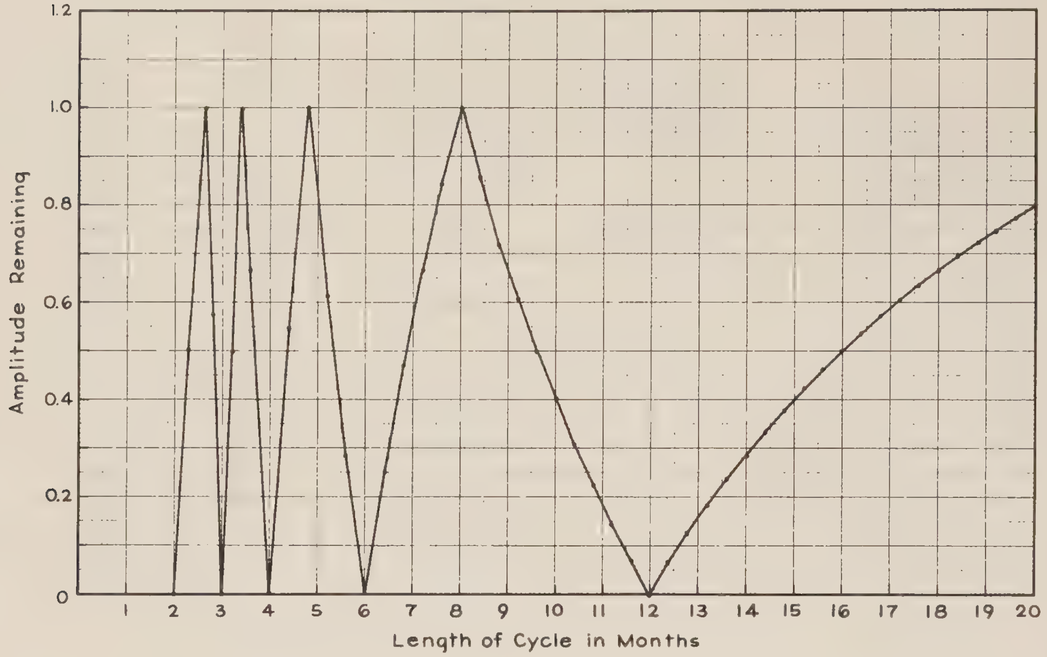

Diagram D

AMPLITUDE CHART

Combined Effect of Four Manipulations

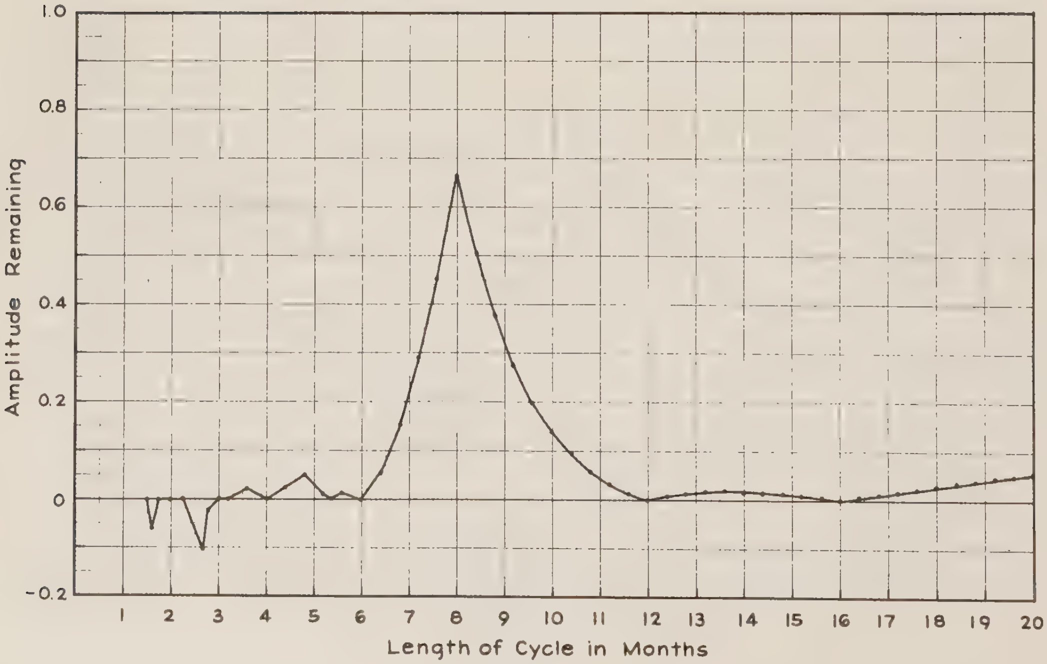

Diagram E

The 25-month weighted moving average has the following effect: Leaves the full amplitude of a 24 month cycle and all odd harmonics of 24 months including 8 months; Reduces to zero the amplitude of a 12 month cycle and all other even harmonics of 24 months: All other cycles are reduced in amplitude as illustrated in Diagram D.

The combined effect of all four manipulations is shown by Diagram E.

TABLE 8

Position Number	Col. A Perfectly regular 8½ month periodicity (amplitude -10 to -10)	Col. B 17-month weighted moving average using weights ¼,0,0,0, 0,0,0,0, ½ 0,0,0, 0,0,0,0, ¼	Col. C 9-month weighted moving average using weights -¼,0,0,0, ½,0,0,0, -¼	Col. D 25-month weighted mov. av. using weights -¼,0,0,0, 0,0,0,0, 0,0,0,0, ½,0,0,0, 0,0,0,0, 0,0,0,0, -¼
1	10.0			
2	5.3			
3	.6			
4	-4.1			
5	-8.8		-8.8	
6	-6.5		-6.5	
7	-1.8		-1.8	
8	2.9		2.9	
9	7.6	7.6	7.6	
10	7.6	7.6	7.6	
11	2.9	2.9	2.9	
12	-1.8	-1.8	-1.8	
13	-6.5	-6.5	-6.5	-6.5
14	-8.8	-8.2	-8.8	-7.6
15	-4.1	-4.1	-4.1	-4.1
16	.6	.6	.6	.6
17	5.3	5.3	5.3	5.3
18	10.0	8.8	9.4	8.3
19	5.3	5.3	5.3	5.3
20	.6	.6	.6	.6
21	-4.1	-4.1	-4.1	-4.1
22	-8.8	-8.2	-8.8	-7.6
23	-6.5	-6.5	-6.5	-6.5
24	-1.8	-1.8	-1.8	-1.8
25	2.9	2.9	2.9	2.9
26	7.6	7.6	7.6	7.0
27	7.6	7.6	7.6	7.0
28	2.9	2.9	2.9	2.9
29	-1.8	-1.8	-1.8	-1.8
30	-6.5	-6.5	-6.5	-6.5
31	-8.8	-8.2	-8.8	
32	-4.1	-4.1	-4.1	
33	.6	.6	.6	
34	5.3	5.3	5.3	
35	10.0		9.4	
36	5.3		5.3	
37	.6		.6	
38	-4.1		-4.1	
39	-8.8			
40	-6.5			
41	-1.8			
42	2.9			

TABLE 9.

Position Number	Col. A A single perfectly regular 8-month wave	Col. B 17-month weighted moving average using weights ¼,0,0,0, 0,0,0,0, ½,0,0,0, 0,0,0,0, ¼	Col. C 9-month weighted moving average using weights -¼,0,0,0, ½,0,0,0, -¼	Col. D 25-month weighted mov. av. using weights -¼,0,0,0, 0,0,0,0, 0,0,0,0, ½,0,0,0, 0,0,0,0, 0,0,0,0, -¼
1	0			
2	0			
3	0			
4	0			
5	0		0	
6	0		0	
7	0		0	
8	0		0	
9	0	0	0	
10	0	0	0	
11	0	0	0	
12	0	0	0	
13	0	0	0	0
14	0	0	0	0
15	0	0	0	1.25
16	0	0	0	2.50
17	0	0	0	1.25
18	0	0	0	0
19	0	-1.25	0	-1.25
20	0	-2.50	0	-2.50
21	0	-1.25	0	-1.25
22	0	0	0	0
23	0	1.25	1.25	0
24	0	2.50	2.50	0
25	0	1.25	1.25	0
26	0	0	0	0
27	- 5	-2.50	-3.75	-2.50
28	-10	-5.00	-7.50	-5.00
29	- 5	2.50	-3.75	-2.50
30	0	0	0	0
31	5	2.50	3.75	2.50
32	10	5.00	7.50	5.00
33	5	2.50	3.75	2.50
34	0	0	0	0
35	0	-1.25	-1.25	0
36	0	-2.50	-2.50	0
37	0	-1.25	-1.25	0
38	0	0	0	0
39	0	1.25	0	1.25
40	0	2.50	0	2.50
41	0	1.25	0	1.25
42	0	0	0	0
43	0	0	0	-1.25
44	0	0	0	-2.50
45	0	0	0	-1.25
46	0	0	0	0
47	0	0	0	
48	0	0	0	
49	0	0	0	
50	0	0	0	
51	0	0	0	
52	0	0	0	
53	0	0	0	
54	0	0	0	
55	0	0		
56	0	0		
57	0	0		
58	0	0		

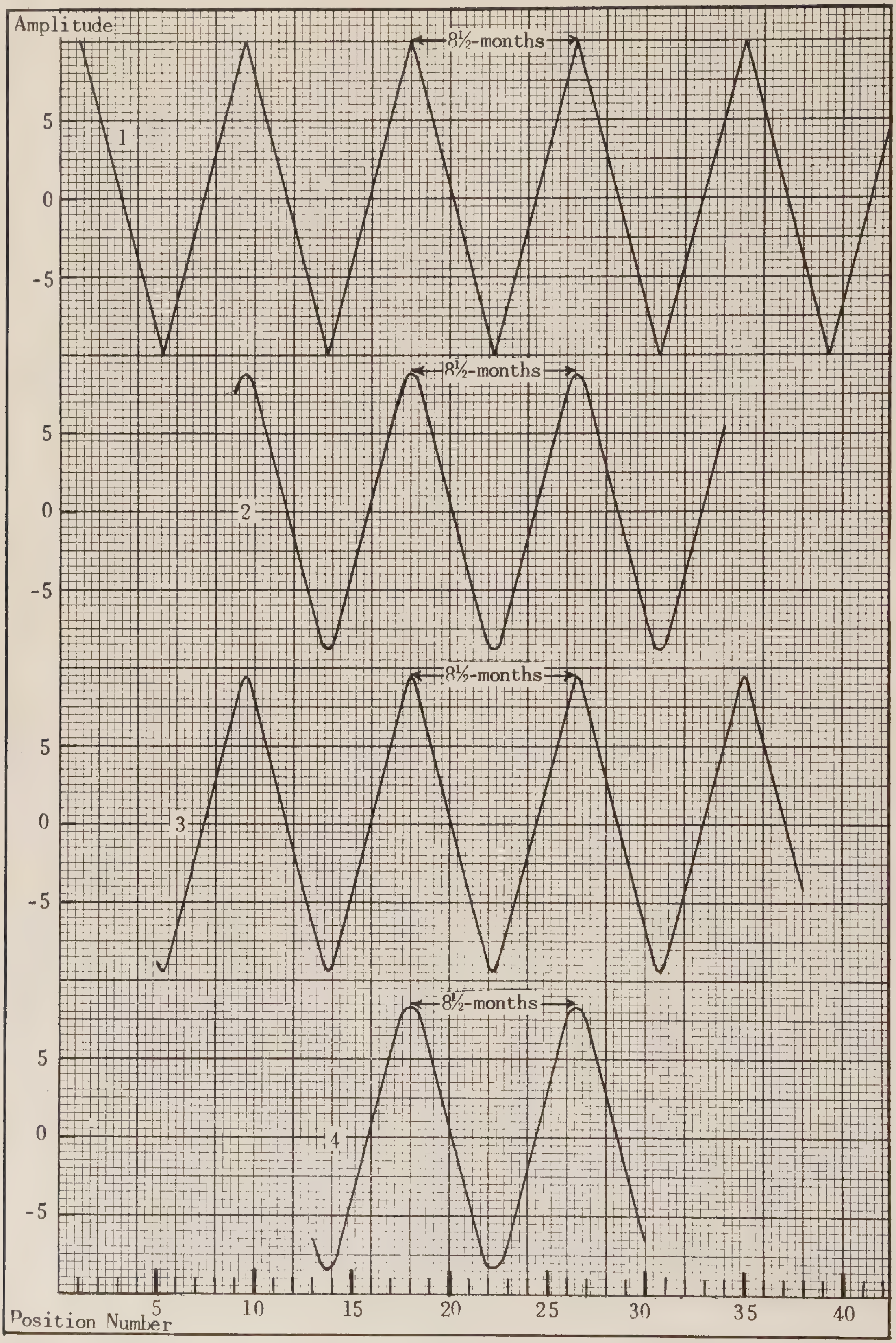

Fig. F. Curve 1 shows a perfectly regular 8½-month periodicity. Curve 2 represents a 17-month weighted moving average of Curve 1. Curve 3 represents a 9-month weighted moving average of Curve 1. Curve 4 represents a 25-month weighted moving average of Curve 1.

It is observed that the length and phase (timing) of the original 8½-month cycle are unaffected, but that the amplitude is slightly reduced.

The effect of the various manipulations upon random numbers is too complex to discuss at this time.

The effect of the various weighted moving averages upon symmetrical periodicities of zigzag shape slightly longer than 8 months is illustrated in Table 8 and diagrammed in Fig. F. It is seen that the length of the periodicity is not affected by the manipulation but that the shape is changed and the amplitude somewhat reduced. A similar effect would have been achieved if we had used a periodicity slightly under 8 months in length.

One final and very important observation needs to be made. This concerns the effect of each of the three weighted moving averages upon a single symmetrical 8-month wave as distinct from a series of such waves which constitute a periodicity. This effect is shown in Table 9 and diagrammed for the 17-month weighted moving average in Fig. G.

With this explanation of the strength and the limitations of the methods used it should be clear that any periodicities about eight months long should be largely free from the distorting effects of other periodicities, if any, so that they can be studied more intelligently and their characteristics determined more accurately.

Such studies of this filtered series have been made and will be reported upon in a subsequent paper.

90 Oak Lane
Rochester New York

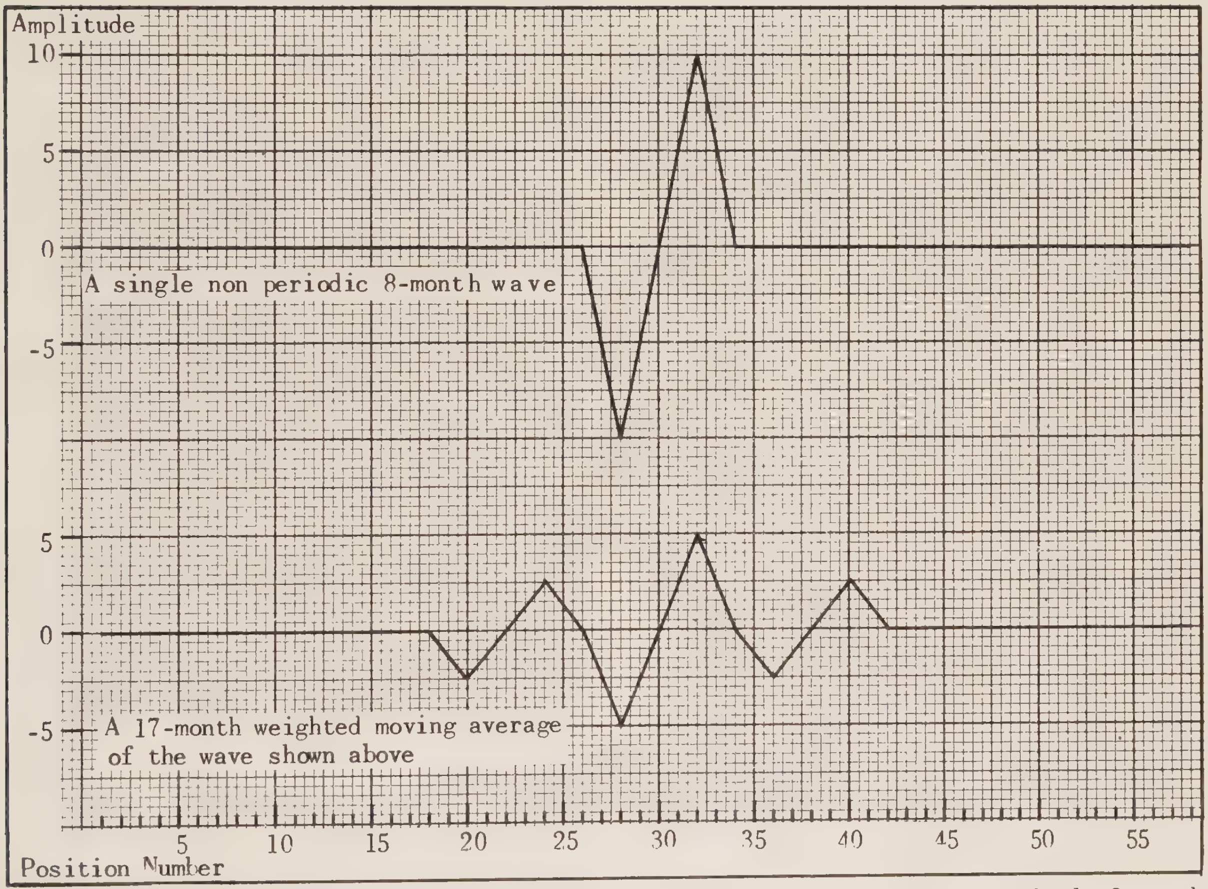

Fig. G shows the effect of a 17-month weighted moving average upon one single 8-month wave.

It is noted that the amplitude of the single wave is reduced one-half and that two spurious waves of one-fourth amplitude eight months away are introduced.

APPENDIX I

RELATIVE SUNSPOT NUMBERS

As supplied by Swiss Federal Observatory, Zurich, Switzerland, and
Published in *Monthly Weather Review*, Vol. 30 *et seq.*

Date	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1749	58.0	62.6	70.0	55.7	85.0	83.5	94.8	66.3	75.9	75.5	158.6	85.2	80.9
1750	73.3	75.9	89.2	88.3	90.0	100.0	85.4	103.0	91.2	65.7	63.3	75.4	83.4
1751	70.0	43.5	45.3	56.4	60.7	50.7	66.3	59.8	23.5	23.2	28.5	44.0	47.7
1752	35.0	50.0	71.0	59.3	59.7	39.6	78.4	29.3	27.1	46.6	37.6	40.0	47.8
1753	44.0	32.0	45.7	38.0	36.0	31.7	22.0	39.0	28.0	25.0	20.0	6.7	30.7
1754	0.0	3.0	1.7	13.7	20.7	26.7	18.8	12.3	8.2	24.1	13.2	4.2	12.2
1755	10.2	11.2	6.8	6.5	0.0	0.0	8.6	3.2	17.8	23.7	6.8	20.0	9.6
1756	12.5	7.1	5.4	9.4	12.5	12.9	3.6	6.4	11.8	14.3	17.0	9.4	10.2
1757	14.1	21.2	26.2	30.0	38.1	12.8	25.0	51.3	39.7	32.5	64.7	33.5	32.4
1758	37.6	52.0	49.0	72.3	46.4	45.0	44.0	38.7	62.5	37.7	43.0	43.0	47.6
1759	48.3	44.0	46.8	47.0	49.0	50.0	51.0	71.3	77.2	59.7	46.3	57.0	54.0
1760	67.3	59.5	74.7	58.3	72.0	48.3	66.0	75.6	61.3	50.6	59.7	61.0	62.9
1761	70.0	91.0	80.7	71.7	107.2	99.3	94.1	91.1	100.7	88.7	89.7	46.0	85.9
1762	43.8	72.8	45.7	60.2	39.9	77.1	33.8	67.7	68.5	69.3	77.8	77.2	61.2
1763	56.5	31.9	34.2	32.9	32.7	35.8	54.2	26.5	68.1	46.3	60.9	61.4	45.1
1764	59.7	59.7	40.2	34.4	44.3	30.0	30.0	30.0	28.2	28.0	26.0	25.7	36.4
1765	24.0	26.0	25.0	22.0	20.2	20.0	27.0	29.7	16.0	14.0	14.0	13.0	20.9
1766	12.0	11.0	36.6	6.0	26.8	3.0	3.3	4.0	4.3	5.0	5.7	19.2	11.4
1767	27.4	30.0	43.0	32.9	29.8	33.3	21.9	40.8	42.7	44.1	54.7	53.3	37.8
1768	53.5	66.1	46.3	42.7	77.7	77.4	52.6	66.8	74.8	77.8	90.6	111.8	69.8
1769	73.9	64.2	64.3	96.7	73.6	94.4	118.6	120.3	148.8	158.2	148.1	112.0	106.1
1770	104.0	142.5	80.1	51.0	70.1	83.3	109.8	126.3	104.4	103.6	132.2	102.3	100.8
1771	36.0	46.2	46.7	64.9	152.7	119.5	67.7	58.5	101.4	90.0	99.7	95.7	81.6
1772	100.9	90.8	31.1	92.2	38.0	57.0	77.3	56.2	50.5	78.6	61.3	64.0	66.5
1773	54.6	29.0	51.2	32.9	41.1	28.4	27.7	12.7	29.3	26.3	40.9	43.2	34.8
1774	46.8	65.4	55.7	43.8	51.3	28.5	17.5	6.6	7.9	14.0	17.7	12.2	30.6
1775	4.4	0.0	11.6	11.2	3.9	12.3	1.0	7.9	3.2	5.6	15.1	7.9	7.0
1776	21.7	11.6	6.3	21.8	11.2	19.0	1.0	24.2	16.0	30.0	35.0	40.0	19.8
1777	45.0	36.5	39.0	95.5	80.3	80.7	95.0	112.0	116.2	106.5	146.0	157.3	92.5
1778	177.3	109.3	134.0	145.0	238.9	171.6	153.0	140.0	171.7	156.3	150.3	105.0	154.4
1779	114.7	165.7	118.0	145.0	140.0	113.7	143.0	112.0	111.0	124.0	114.0	110.0	125.9
1780	70.0	98.0	98.0	95.0	107.2	88.0	86.0	86.0	93.7	77.0	60.0	58.7	84.8
1781	98.7	74.7	53.0	68.3	104.7	97.7	73.5	66.0	51.0	27.3	67.0	35.2	68.1
1782	54.0	37.5	37.0	41.0	54.3	38.0	37.0	44.0	34.0	23.2	31.5	30.0	38.5
1783	28.0	38.7	26.7	28.3	23.0	25.2	32.2	20.0	18.0	8.0	15.0	10.5	22.8
1784	13.0	8.0	11.0	10.0	6.0	9.0	6.0	10.0	10.0	8.0	17.0	14.0	10.2
1785	6.5	8.0	9.0	15.7	20.7	26.3	36.3	20.0	32.0	47.2	40.2	27.3	24.1
1786	37.2	47.6	47.7	85.4	92.3	59.0	83.0	89.7	111.5	112.3	116.0	112.7	82.9
1787	134.7	106.0	87.4	127.2	134.8	99.2	128.0	137.2	157.3	157.0	141.5	174.0	132.0
1788	138.0	129.2	143.3	108.5	113.0	154.2	141.5	136.0	141.0	142.0	94.7	129.5	130.9
1789	114.0	125.3	120.0	123.3	123.5	120.0	117.0	103.0	112.0	89.7	134.0	135.5	118.1
1790	103.0	127.5	96.3	94.0	93.0	91.0	69.3	87.0	77.3	84.3	82.0	74.0	89.9
1791	72.7	62.0	74.0	77.2	73.7	64.2	71.0	43.0	66.5	61.7	67.0	66.0	66.6
1792	58.0	64.0	63.0	75.7	62.0	61.0	45.8	60.0	59.0	59.0	57.0	56.0	60.0
1793	56.0	55.0	55.5	53.0	52.3	51.0	50.0	29.3	24.0	47.0	44.0	45.7	46.9
1794	45.0	44.0	38.0	28.4	55.7	41.5	41.0	40.0	11.1	28.5	67.4	51.4	41.0
1795	21.4	39.9	12.6	18.6	31.0	17.1	12.9	25.7	13.5	19.5	25.0	18.0	21.3
1796	22.0	23.8	15.7	31.7	21.0	6.7	26.9	1.5	18.4	11.0	8.4	5.1	16.0
1797	14.4	4.2	4.0	4.0	7.3	11.1	4.3	6.0	5.7	6.9	5.8	3.0	6.4
1798	2.0	4.0	12.4	1.1	0.0	0.0	0.0	3.0	2.4	1.5	12.5	9.9	4.1
1799	1.6	12.6	21.7	8.4	8.2	10.6	2.1	0.0	0.0	4.6	2.7	8.6	6.8
1800	6.9	9.3	13.9	0.0	5.0	23.7	21.0	19.5	11.5	12.3	10.5	40.1	14.5
1801	27.0	29.0	30.0	31.0	32.0	31.2	35.0	38.7	33.5	32.6	39.8	48.2	34.0
1802	47.8	47.0	40.8	42.0	44.0	46.0	48.0	50.0	51.8	38.5	34.5	50.0	45.0
1803	50.0	50.8	29.5	25.0	44.3	36.0	48.3	34.1	45.3	54.3	51.0	48.0	43.1
1804	45.3	48.3	48.0	50.6	33.4	34.8	29.8	43.1	53.0	62.3	61.0	60.0	47.5
1805	61.0	44.1	51.4	37.5	39.0	40.5	37.6	42.7	44.4	29.4	41.0	38.3	42.2
1806	39.0	29.6	32.7	27.7	26.4	25.6	30.0	26.3	24.0	27.0	25.0	24.0	28.1
1807	12.0	12.2	9.6	23.8	10.0	12.0	12.7	12.0	5.7	8.0	2.6	0.0	10.1
1808	0.0	4.5	0.0	12.3	13.5	13.5	6.7	8.0	11.7	4.7	10.5	12.3	8.1
1809	7.2	9.2	0.9	2.5	2.0	7.7	0.3	0.2	0.4	0.0	0.0	0.0	2.5
1810	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1811	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0	2.4	6.1	0.8	1.1	1.4
1812	11.3	1.9	0.7	0.0	1.0	1.3	0.5	15.6	5.2	3.9	7.9	10.1	5.0
1813	0.0	10.3	1.9	16.6	5.5	11.2	18.3	8.4	15.3	27.8	16.7	14.3	12.2
1814	22.2	12.0	5.7	23.8	5.8	14.9	18.5	2.3	8.1	19.3	14.5	20.1	13.9
1815	19.2	32.2	26.2	31.6	9.8	55.9	35.5	47.2	31.5	33.5	37.2	65.0	35.4
1816	26.3	68.8	73.7	58.8	44.3	43.6	38.8	23.2	47.8	56.4	38.1	29.9	45.8
1817	36.4	57.9	96.2	26.4	21.2	40.0	50.0	45.0	36.7	25.6	28.9	28.4	41.1
1818	34.9	22.4	29.7	34.5	53.1	36.4	28.0	31.5	26.1	31.7	10.9	25.8	30.4
1819	32.5	20.7	3.7	20.2	19.6	35.0	31.4	26.1	14.9	27.5	25.1	30.6	23.9
1820	19.2	26.6	4.5	19.4	29.3	10.8	20.6	25.9	5.2	9.0	7.9	9.7	15.7
1821	21.5	4.3	5.7	9.2	1.7	1.8	2.5	4.8	4.4	18.8	4.4	0.0	6.6
1822	0.0	0.9	16.1	13.5	1.5	5.6	7.9	2.1	0.0	0.4	0.0	0.0	4.0
1823	0.0	0.0	0.6	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	20.4	1.8
1824	21.6	10.8	0.0	19.4	2.8	0.0	0.0	1.4	20.5	25.2	0.0	0.8	8.5
1825	5.0	15.5	22.4	3.8	15.4	15.4	30.9	25.4	15.7	15.6	11.7	22.0	16.6
1826	17.7	18.2	36.7	24.0	32.4	37.1	52.5	39.6	18.9	50.6	39.5	68.1	36.3
1827	34.6	47.4	57.8	46.0	56.3	56.7	42.9	53.7	49.6	57.2	48.2	46.1	49.7
1828	52.8	64.4	65.0	61.1	89.1	98.0	54.3	76.4	50.4	34.7	57.0	46.9	62.5
1829	43.0	49.4	72.3	95.0	67.5	73.9	90.8	78.3	52.8	57.2	67.6	56.5	67.0
1830	52.2	72.1	84.6	107.1	66.3	65.1	43.9	50.7	62.1	84.4	81.2	82.1	71.0
1831	47.5	50.1	93.4	54.6	38.1	33.4	45.2	54.9	37.9	46.2	43.5	28.9	47.8
1832	30.9	55.5	55.1	26.9	41.3	26.7	13.9	8.9	8.2	21.1	14.3	27.5	27.5
1833	11.3	14.9	11.8	2.8	12.9	1.0	7.0	5.7	11.6	7.5	5.9	9.9	8.5
1834	4.9	18.1	3.9	1.4	8.8	7.8	8.7	4.0	11.5	24.8	30.5	34.5	13.2
1835	7.5	24.5	19.7	61.5	43.6	33.2	59.8	59.0	100.8	95.2	100.0	77.5	56.9
1836	88.6	107.6	98.1	142.9	111.4	124.7	116.7	107.8	95.1	137.4	120.9	206.2	121.5
1837	188.0	175.6	134.6	138.2	111.3	158.0	162.8	134.0	96.3	123.7	107.0	129.8	138.3
1838	144.9	84.8	140.8	126.6	137.6	94.5	108.2	78.8	73.6	90.8	77.4	79.8	103.2
1839	107.6	102.5	77.7	61.8	53.8	54.6	84.7	131.2	132.7	90.8	68.8	63.6	85.8
1840	81.2	87.7	55.5	65.9	69.2	48.5	60.7	57.8	74.0	49.8	54.3	53.7	63.2
1841	24.0	29.9	29.7	42.6	67.4	55.7	30.8	39.3	35.1	28.5	19.8	38.8	36.8
1842	20.4	22.1	21.7	26.9	24.9	20.5	12.6	26.5	18.5	38.1	40.5	17.6	24.2
1843	13.3	3.5	8.3	8.8	21.1	10.5	9.5	11.8	4.2	5.3	19.1	12.7	10.7
1844	9.4	14.7	13.6	20.8	12.0	3.7	21.2	23.9	6.9	21.5	10.7	21.6	15.0
1845	25.7	43.6	43.3	56.9	47.8	31.1	30.6	32.3	29.6	40.7	39.4	59.7	40.1
1846	38.7	51.0	63.9	69.2	59.9	65.1	46.5	54.8	107.1	55.9	60.4	65.5	61.5
1847	62.6	44.9	85.7	44.7	75.4	85.3	52.2	140.6	161.2	180.4	138.9	109.6	98.5
1848	159.1	111.8	108.9	107.1	102.2	123.8	139.2	132.5	100.3	132.4	114.6	159.9	124.3
1849	156.7	131.7	96.5	102.5	80.6	81.2	78.0	61.3	93.7	71.5	99.7	97.0	95.9
1850	78.0	89.4	82.6	44.1	61.6	70.0	39.1	61.6	86.2	71.0	54.8	60.0	66.5
1851	75.5	105.4	64.6	56.5	62.6	63.2	36.1	57.4	67.9	62.5	50.9	71.4	64.5
1852	68.4	67.5	61.2	65.4	54.9	46.9	42.0	39.7	37.5	67.3	54.3	45.4	54.2
1853	41.1	42.9	37.7	47.6	34.7	40.0	45.9	50.4	33.5	42.3	28.8	23.4	39.0
1854	15.4	20.0	20.7	26.4	24.0	21.1	18.7	15.8	22.4	12.7	28.2	21.4	20.6
1855	12.3	11.4	17.4	4.4	9.1	5.3	0.4	3.1	0.0	9.7	4.2	3.1	6.7
1856	0.5	4.9	0.4	6.5	0.0	5.0	4.6	5.9	4.4	4.5	7.7	7.2	4.3
1857	13.7	7.4	5.2	11.1	29.2	16.0	22.2	16.9	42.4	40.6	31.4	37.2	22.8
1858	39.0	34.9	57.5	38.3	41.4	44.5	56.7	55.3	80.1	91.2	51.9	66.9	54.8
1859	83.7	87.6	90.3	85.7	91.0	87.1	95.2	106.8	105.8	114.6	97.2	81.0	93.8
1860	81.5	88.0	98.9	71.4	107.1	108.6	116.7	100.3	92.2	90.1	97.9	95.6	95.7
1861	62.3	77.8	101.0	98.5	56.8	87.8	78.0	82.5	79.9	67.2	53.7	80.5	77.2
1862	63.1	64.5	43.6	53.7	64.4	84.0	73.4	62.5	66.6	42.0	50.6	40.9	59.1
1863	48.3	56.7	66.4	40.6	53.8	40.8	32.7	48.1	22.0	39.9	37.7	41.2	44.0
1864	57.7	47.1	66.3	35.8	40.6	57.8	54.7	54.8	28.5	33.9	57.6	28.6	47.0
1865	48.7	39.3	39.5	29.4	34.5	33.6	26.8	37.8	21.6	17.1	24.6	12.8	30.5
1866	31.6	38.4	24.6	17.6	12.9	16.5	9.3	12.7	7.3	14.1	9.0	1.5	16.3
1867	0.0	0.7	9.2	5.1	2.9	1.5	5.0	4.9	9.8	13.5	9.3	25.2	7.3
1868	15.6	15.8	26.5	36.6	26.7	31.1	28.6	34.4	43.8	61.7	59.1	67.6	37.3
1869	60.9	59.3	52.7	41.0	104.0	108.4	59.2	79.6	80.6	59.4	77.4	104.3	73.9
1870	77.3	114.9	159.4	160.0	176.0	135.6	132.4	153.8	136.0	146.4	147.5	130.0	139.1
1871	88.3	125.3	143.2	162.4	145.5	91.7	103.0	110.0	80.3	89.0	105.4	90.3	111.2
1872	79.5	120.1	88.4	102.1	107.6	109.9	105.5	92.9	114.6	103.5	112.0	83.9	101.7
1873	86.7	107.0	98.3	76.2	47.9	44.8	66.9	68.2	47.5	47.4	55.4	49.2	66.3
1874	60.8	64.2	46.4	32.0	44.6	38.2	67.8	61.3	28.0	34.3	28.9	29.3	44.7
1875	14.6	22.2	33.8	29.1	11.5	23.9	12.5	14.6	2.4	12.7	17.7	9.9	17.1

Date	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1876	14.3	15.0	31.2	2.3	5.1	1.6	15.2	8.8	9.9	14.3	9.9	8.2	11.3
1877	24.4	8.7	11.7	15.8	21.2	13.4	5.9	6.3	16.4	6.7	14.5	2.3	12.3
1878	3.3	6.0	7.8	0.1	5.8	6.4	0.1	0.0	5.3	1.1	4.1	0.5	3.4
1879	0.8	0.6	0.0	6.2	2.4	4.8	7.5	10.7	6.1	12.3	12.9	7.2	6.0
1880	24.0	27.5	19.5	19.3	23.5	34.1	21.9	48.1	66.0	43.0	30.7	29.6	32.3
1881	36.4	53.2	51.5	51.7	43.5	60.5	76.9	58.0	53.2	64.0	54.8	47.3	54.3
1882	45.0	69.3	67.5	95.8	64.1	45.2	45.4	40.4	57.7	59.2	84.4	41.8	59.7
1883	60.6	46.9	42.8	82.1	32.1	76.5	80.6	46.0	52.6	83.8	84.5	75.9	63.7
1884	91.5	86.9	86.8	76.1	66.5	51.2	53.1	55.8	61.9	47.8	36.6	47.2	63.5
1885	42.8	71.8	49.8	55.0	73.0	83.7	66.5	50.0	39.6	38.7	33.3	21.7	52.2
1886	29.9	25.9	57.3	43.7	30.7	27.1	30.3	16.9	21.4	8.6	0.3	12.4	25.4
1887	10.3	13.2	4.2	6.9	20.0	15.7	23.3	21.4	7.4	6.6	6.9	20.7	13.1
1888	12.7	7.1	7.8	5.1	7.0	7.1	3.1	2.8	8.8	2.1	10.7	6.7	6.8
1889	0.8	8.5	7.0	4.3	2.4	6.4	9.7	20.6	6.5	2.1	0.2	6.7	6.3
1890	5.3	0.6	5.1	1.6	4.8	1.3	11.6	8.5	17.2	11.2	9.6	7.8	7.1
1891	13.5	22.2	10.4	20.5	41.1	48.3	58.8	33.2	53.8	51.5	41.9	32.2	35.6
1892	69.1	75.6	49.9	69.6	79.6	76.3	76.8	101.4	62.8	70.5	65.4	78.6	73.0
1893	75.0	73.0	65.7	88.1	84.7	88.2	88.8	129.2	77.9	79.7	75.1	93.8	84.9
1894	83.2	84.6	52.3	81.6	101.2	98.9	106.0	70.3	65.9	75.5	56.6	60.0	78.0
1895	63.3	67.2	61.0	76.9	67.5	71.5	47.8	68.9	57.7	67.9	47.2	70.7	64.0
1896	29.0	57.4	52.0	43.8	27.7	49.0	45.0	27.2	61.3	28.4	38.0	42.6	41.8
1897	40.6	29.4	29.1	31.0	20.0	11.3	27.6	21.8	48.1	14.3	8.4	33.3	26.2
1898	30.2	36.4	38.3	14.5	25.8	22.3	9.0	31.4	34.8	34.4	30.9	12.6	26.7
1899	19.5	9.2	18.1	14.2	7.7	20.5	13.5	2.9	8.4	13.0	7.8	10.5	12.1
1900	9.4	13.6	8.6	16.0	15.2	12.1	8.3	4.3	8.3	12.9	4.5	0.3	9.5
1901	0.2	2.4	4.5	0.0	10.2	5.8	0.7	1.0	0.6	3.7	3.8	0.0	2.7
1902	5.2	0.0	12.4	0.0	2.8	1.4	0.9	2.3	7.6	16.3	10.3	1.1	5.0
1903	8.3	17.0	13.5	26.1	14.6	16.3	27.9	28.8	11.1	38.9	44.5	45.6	24.4
1904	31.6	24.5	37.2	43.0	39.5	41.9	50.6	58.2	30.1	54.2	38.0	54.6	42.0
1905	54.8	85.8	56.5	39.3	48.0	49.0	73.0	58.8	55.0	78.7	107.2	55.5	63.5
1906	45.5	31.3	64.5	55.3	57.7	63.2	103.3	47.7	56.1	17.8	38.9	64.7	53.8
1907	76.4	108.2	60.7	52.6	43.0	40.4	49.7	54.3	85.0	65.4	61.5	47.3	62.0
1908	39.2	33.9	28.7	57.6	40.8	48.1	39.5	90.5	86.9	32.3	45.5	39.5	48.5
1909	56.7	46.6	66.3	32.3	36.0	22.6	35.8	23.1	38.8	58.4	55.8	54.2	43.9
1910	26.4	31.5	21.4	8.4	22.2	12.3	14.1	11.5	26.2	38.3	4.9	5.8	18.6
1911	3.4	9.0	7.8	16.5	9.0	2.2	3.5	4.0	4.0	2.6	4.2	2.2	5.7
1912	0.3	0.0	4.9	4.5	4.4	4.1	3.0	0.3	9.5	4.6	1.1	6.4	3.6
1913	2.3	2.9	0.5	0.9	0.0	0.0	1.7	0.2	1.2	3.1	0.7	3.8	1.4
1914	2.5	2.6	3.1	17.3	5.3	11.4	5.4	7.8	12.8	8.1	16.1	22.2	9.6
1915	23.0	42.3	38.8	41.3	33.0	68.8	71.6	69.6	49.5	53.5	42.5	34.5	47.4
1916	45.3	55.4	67.0	71.8	74.5	67.7	53.5	35.2	45.1	50.7	65.6	53.0	55.4
1917	74.7	71.9	94.8	74.7	114.1	114.9	119.8	154.5	129.4	72.2	96.4	129.3	103.9
1918	96.0	65.3	72.2	80.5	76.7	59.4	107.6	101.7	79.9	85.0	83.4	59.2	80.6
1919	48.1	79.5	66.5	51.8	88.1	111.2	64.7	69.0	54.7	52.8	42.0	34.9	63.6
1920	57.3	50.9	71.9	14.3	33.7	38.8	26.5	18.6	38.7	48.8	24.6	39.9	38.7
1921	28.8	27.6	27.5	30.5	22.3	34.5	42.4	20.8	16.7	16.1	13.4	15.7	24.7
1922	10.2	27.9	60.0	11.4	7.7	5.8	9.7	5.3	5.2	8.1	6.7	18.7	14.7
1923	4.5	1.5	3.3	6.1	3.2	9.1	3.5	0.5	13.2	11.6	10.0	2.8	5.8
1924	0.5	5.1	1.8	11.3	20.8	24.0	28.1	19.3	25.1	25.6	22.5	16.5	16.7
1925	5.5	23.2	18.0	31.7	42.8	47.5	38.5	37.9	60.2	69.2	58.6	98.6	44.3
1926	71.8	70.0	62.5	38.5	64.3	73.5	52.3	61.6	60.8	71.5	60.5	79.4	63.9
1927	81.6	93.0	69.6	93.5	79.1	59.1	54.9	53.8	68.4	63.1	67.2	45.2	69.0
1928	83.5	73.5	85.4	80.6	76.9	91.4	98.0	83.8	89.7	61.4	50.3	59.0	77.8
1929	68.9	64.1	50.2	52.8	58.2	71.9	70.2	65.8	34.4	54.0	81.1	108.0	65.0
1930	65.3	49.2	35.0	38.2	36.9	28.8	21.9	24.9	32.1	34.4	35.6	25.8	35.7
1931	14.6	43.1	30.0	31.2	24.6	15.3	17.4	13.0	19.0	10.0	18.7	17.8	21.2
1932	12.1	10.6	11.2	11.2	17.9	22.2	9.6	6.8	4.0	8.9	8.2	11.0	11.1
1933	12.3	22.2	10.1	2.9	3.2	5.2	2.8	0.2	5.1	3.0	0.6	0.3	5.7
1934	3.4	7.8	4.3	11.3	19.7	6.7	9.3	8.3	4.0	5.7	8.7	15.4	8.7
1935	18.9	20.5	23.1	12.2	27.3	45.7	33.9	30.1	42.1	53.2	64.2	61.5	36.1
1936	60.4	73.8	77.7	77.1	54.1	70.5	52.4	67.6	75.1	85.5	113.4	117.5	79.7
1937	132.5	128.5	83.9	109.3	116.7	130.3	145.1	137.7	100.7	124.9	74.4	88.8	114.4
1938	98.4	119.2	86.5	101.0	127.4	97.5	165.3	115.7	89.6	99.1	122.2	92.7	109.6
1939	80.3	77.4	64.6	109.1	118.3	101.0	97.6	105.8	112.6	88.1	68.1	42.1	88.8
1940	50.5	59.4	83.3	60.7	54.4	83.9	67.5	105.5	66.5	55.0	58.4	68.3	67.8
1941	45.6	44.5	46.4	32.8	29.5	59.8	66.9	60.0	65.9	46.3	38.3	33.7	47.5
1942	35.6	52.8	54.2	60.7	25.0	11.4	17.7	20.2	17.2	19.2	30.7	22.5	30.6
1943	12.4	28.9	27.4	26.1	14.1	7.6	13.2	19.4	10.0	7.8	10.2	18.8	16.3
1944	3.7	0.5	11.0	0.3	2.5	5.0	5.0	16.7	14.3	16.9	10.8	28.4	9.6
1945	18.5	12.7	21.5	32.0	30.6	36.2	42.6	25.9	34.9	68.8	46.0	27.4	33.1
1946*	47.6	84.9	75.3	75.2	84.4	72.9	115.2	107.2	94.0	102.1	125.0	121.7	92.1
1947	116.0	132.3	129.8	149.9	206.5	168.9	168.6	196.1	175.5	181.6	127.4	116.6	155.8
1948	105.4	87.3	95.7	189.5	179.4	167.6	141.1	155.4	143.2	136.5	93.2	139.8	136.2
1949	119.4	183.3	158.1	148.9	104.7	123.5	125.8	130.9	151.6	131.9	139.0	118.9	136.4
1950	98.8	94.6	108.9	113.1	104.8	83.2	91.0	85.2	49.3	61.2	54.6	54.5	83.3

*Provisional numbers start at January, 1946.

AMPLITUDE TABLE

FOR DIAGRAMS A, B, C, D, & E.

	A	B	C	D	E
LENGTH OF CYCLE IN MONTHS	3 MONTH	17 MONTH	9 MONTH	25 MONTH	AxBxC xD
20.0	.8667	.2000	.4000	.8000	.0555
19.6	.8639	.1836	.4082	.7755	.0502
19.2	.8611	.1667	.4167	.7500	.0449
18.8	.8581	.1489	.4254	.7234	.0393
18.4	.8551	.1304	.4348	.6957	.0337
18.0	.8518	.1111	.4444	.6667	.0280
17.6	.8485	.0909	.4545	.6364	.0223
17.2	.8450	.0698	.4651	.6047	.0166
16.8	.8413	.0476	.4762	.5714	.0109
16.4	.8374	.0244	.4878	.5366	.0054
16.0	.8333	.0000	.5000	.5000	.0000
15.6	.8291	.0256	.5128	.4615	.0054
15.2	.8246	.0526	.5263	.4211	.0096
14.8	.8198	.0811	.5405	.3784	.0136
14.4	.8148	.1111	.5555	.3333	.0168
14.0	.8095	.1429	.5714	.2857	.0189
13.6	.8039	.1765	.5882	.2353	.0195
13.2	.7980	.2121	.6061	.1818	.0187
12.8	.7917	.2500	.6250	.1250	.0154
12.4	.7849	.2903	.6451	.0645	.0095
12.0	.7778	.3333	.6667	.0000	.0000
11.6	.7701	.3793	.6897	.0690	.0139
11.2	.7619	.4286	.7143	.1429	.0333
10.8	.7531	.4815	.7407	.2222	.0596
10.4	.7436	.5385	.7692	.3077	.0947
10.0	.7333	.6000	.8000	.4000	.1408
9.6	.7222	.6667	.8333	.5000	.2006
9.2	.7101	.7391	.8696	.6087	.2778
8.8	.6970	.8182	.9091	.7273	.3771
8.4	.6825	.9048	.9524	.8571	.5041
8.0	.6667	1.0000	1.0000	1.0000	.6667
7.6	.6491	.8947	.9474	.8422	.4633
7.2	.6296	.7778	.8889	.6667	.2903
6.8	.6078	.6471	.8235	.4706	.1524
6.4	.5833	.5050	.7500	.2500	.0547
6.0	.5555	.3333	.6667	.0000	.0000
5.6	.5238	.1429	.5714	.2857	.0122
5 1/3	.5125	.0000	.5185	.4444	.0000
5.2	.4872	.0769	.4615	.6154	.0106
4.8	.4444	.3333	.3333	1.0000	.0494
4.4	.3939	.6364	.1818	.5455	.0249
4.0	.3333	1.0000	.0000	.0000	.0000
3.6	.2593	.5555	.2222	.6667	.0231
3.2	.1667	.0000	.5000	.5000	.0000
3.0	.0000	.3333	.6667	.0000	.0000
2.8	.0650	.7143	.8571	.5714	-.0227
2 2/3	.1000	1.0000	1.0000	1.0000	-.1000
2.2857	.1600	.0000	.5000	.5000	.0000
2.0	.1650	1.0000	.0000	.0000	.0000
1.7778	.1300	.0000	.5000	.5000	.0000
1.6	.0600	1.0000	1.0000	1.0000	.0600
1.5	.0000				.0000

RÉSUMÉ OF CYCLES-A MONTHLY REPORT

March 1952

The **Director's Letter** sets forth some of the changes that he would make if he and Mr. Dakin were rewriting **Cycles—The Science of Prediction**.

The **Research** section contains three articles as follows:

1. Planetary Effects on Shortwave Radio.
2. What Made the Benner Forecast Tick?
3. The 12-Month Cycle in the Sales of Company G.

The first article, "Planetary Effects on Shortwave Radio," by John H. Nelson, describes a method of forecasting radio weather which is about 80% accurate. This forecasting method is based chiefly upon correspondences which Nelson discovered between planetary relationships and shortwave radio signal behavior.

The second article discusses the remarkable forecast of pig iron prices made by Samuel Benner in 1874. This forecast achieved its success in part because of a cycle in these prices of about 9 years in length which continued after 1874, and in part because of other cycles which also continued, which must have lengths about 1/2, 1/4, 1/5, 1/6 or some other unit fraction of 27 years. The task ahead is to find these other cycles; then to make a new forecast, starting now.

The third research article discusses the 12.6-month cycle in the sales of Company G. This cycle has been present in the sales of this company since 1904.

The **Technical** section contains two articles, "Cycle Analysis for the Beginner" and "The Techniques Involved in the Determination of the 12.6-Month Cycle in the Sales of Company G."

The report ends with a resume of Vol. I, No. 2 of the **Journal of Cycle Research**, **Letters**, and **Additions to the Library**.

April 1952

The **Director's Letter** discusses four things: 1, It explains the difference between two projections of stock market cycles; 2, it comments on the present stock market situation; 3, it comments on the present business situation; and 4, it finishes the discussion begun in March of the changes the Director would make in **Cycles—The Science of Prediction** if that book were being rewritten at the present time.

The **Research** section contains four articles, viz:

1. Possible Cycles in Railroad Stock Prices, 1831—1950.
2. The Effect of Atmospheric Electricity Upon Business.
3. Cycles in Women's Dress Fashions.
4. The 11.2-Year Cycle in International War, 1750—1950.

The first article, in regard to possible cycles in railroad stock prices, presents a periodogram of a multiple harmonic analysis of railroad stock prices, 1831—1950. It lists the cycles suggested by this harmonic analysis.

The second article, by the late Ellsworth Huntington, reprints part of an article written by him which suggests a possible interrelationship between atmospheric electricity and human reactions.

The third article brings up to date a book by Agnes Brooks Young and shows how forecasts made by Mrs. Young in 1937 have worked out in the 15 years since this book was printed.

The fourth article discusses an 11.2-year cycle in international war which has been present in the index of international war since about 1750.

The **Technical** section discusses (a) the techniques involved in the construction of the periodogram of railroad stock prices and (b) the techniques involved in the determination of the 11.2-year cycle in the number of international battles.

The **Data** section gives (a) recent industrial common stock prices, trend, and deviations from trend, (b) the Foundation for the Study of Cycles' Index of Railroad Stock Prices, 1831—1951, and (c) a chart showing U.S. wholesale commodity price index during major war periods.

The issue concludes with **Foundation Affairs**, **Letters**, **Questions** and **Answers**, and **Additions to the Library**.

May 1952

The **Director's Letter** suggests some reasons why people may be so intrigued by the subject of cycles.

The **Research** section contains four articles as follows:

The 17¾-Year Cycle in Pig Iron Prices, 1784—1951.

Possible Cycles in Industrial Stock Prices, 1871—1950.

The 9.6-Year Cycle of Game Abundance.

The 14-Day Cycle in the Amorousness of Women.

The article on the 17¾-year cycle in pig iron prices is a condensation of the article which appeared in the Spring 1952 issue of the **Journal of Cycle Research.**

The second research article presents six periodograms obtained by multiple harmonic analyses of industrial common stock prices, 1871—1950.

The third article digests a recent paper by R. M. Ferrie called "Upland Game in Western Canada" and shows that another 9.6-year cycle in game abundance seems to have been completed.

The fourth article consists of excerpts from a book by Dr. Marie C. Stopes.

The issue concludes with **Foundation Affairs, Letters, Questions and Answers,** and **Additions to the Library.**

June 1952

The **Director's Letter** announces the free distribution of Journals to libraries and to all who have contributed to the fund of knowledge in regard to cycles, rhythms, and/or periodicities. It also announces a Fellowship available for the study of cycles.

The **Research** section contains four articles, viz:

1. A Stock Market Forecast Made in 1912.
2. The 142-Year Cycle in War.
3. Is There a 17 1/3-Year Pattern in Stocks?

Possible Cycle in Pig Iron Prices, 1784—1951.

The first article discusses a cycle analysis of railroad stock prices made in 1912 which isolated and projected cycles 20 years long, 41 months long, 14.45 months long, and 8.2 months long. If anyone had followed this forecast for medium term moves, he would have built $1,000 up to $10,869 (disregarding brokerage) in the 31 years which followed.

By 1943, however, this forecast had got out of step with reality. Until revised it cannot be relied upon.

The second article discusses a cycle of about 142 years which has been present in the index of international battles from 1 B. C. to date and synthesized the four cycles in international wars which have been reported upon in previous issues.

The third article prints some charts of Mr. W. E. D. Stokes, Jr. who has observed some tendency for a 17 1/3-year pattern in industrial common stock prices to repeat.

The fourth article prints a periodogram to show the results of a multiple harmonic analysis of pig iron prices, 1784—1951 and lists the various cycles suggested by the periodogram.

A new department called "How has it worked out?" brings up to date two charts published previously, namely the chart showing the 57-year cycle in international conflict and the 33-month cycle in residential building construction.

The **Technical** section discusses the techniques involved in the January 1952 article entitled the 37-year cycle in the frequency of Chinese earthquakes.

The issue concludes with **Letters, Questions and Answers,** and **Additions to the Library.**

19 1952

FELLOWSHIP AVAILABLE!

The Foundation announces the creation of three Fellowships, each to run for three years. These Fellowships were created to enable qualified students to spend full time at Foundation headquarters in the study of the subject of cycles.

One of these Fellowships has already been financed. The problem now is to find a suitable Fellow. Are you interested or do you know of anyone who might be interested?

The Fellow will live, rent free, in an 8-room house adjacent to research headquarters of the Foundation at East Brady, Pennsylvania, and will receive a stipend adequate for the support of himself and his family. If you are interested, write to the Director of the Foundation, giving your qualifications and the amount of money that you would require.

If you are not interested yourself, please try to get some other qualified person to make an application.

Foundation for the Study of Cycles
Research Headquarters
East Brady, Pennsylvania